

POLYZOA FROM WEST AFRICA
NOTES ON THE GENERA *HIPPOPORINA*
NEVIANI, *HIPPOPORELLA* CANU,
CLEIDOCHASMA HARMER AND
HIPPOPORIDRA CANU & BASSLER
(CHEILOSTOMATA, ASCOPHORA)



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By PATRICIA L. COOK

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I. INTRODUCTION

POLYZOA from the north and north-western coasts of Africa and from the neighbouring islands, have been described ; but there has been hitherto no systematic collection from the coast of southern Senegal and the Gulf of Guinea. The collections here

described consist of the "Calypso" Collection I, from Senegal and the Bay of Biafra, and Collection II, from the Cape Verde Islands; the Marche-Marchad Collections, from Senegal; and the Achimota Collection, from Ghana (see Cook, 1964 : 44).

The holotypes of new species, together with representative specimens of all the material described, are deposited in the British Museum (Natural History).

Material was treated with eau de javelle for examination of calcareous parts, and decalcified and stained to show chitinous parts. The following measurements were made where possible :

Length of zooecium . . .	Lz	Width of operculum . . .	lop
Width of zooecium . . .	lz	Length of avicularium . . .	La
Length of orifice . . .	Lo	Length of mandible . . .	Lm
Width of orifice . . .	lo	Length of ovicell . . .	Lov
Length of operculum . . .	Lop	Width of ovicell . . .	lov

Specimens in the British Museum, Zoology Department, are referred to by their registered numbers, thus : 1911.10.1.1134, and in the Palaeontology Department thus : B 1620.

Species assigned by various authors to *Hippoporina* belong to three distinct genera. These were defined by Harmer (1957 : 977 and 1038), and their synonymies may be summarized as follows :—

1. *Hippoporina* Neviani 1895, type-species *Cellepora pertusa* Esper (= ? *Hippodiplosia* Canu, 1916, type-species *H. verrucosa* Canu, chosen by Hastings, 1930. If *Hippodiplosia verrucosa* is congeneric with *Hippoporina pertusa*, *Hippodiplosia* is a synonym of *Hippoporina*, but this is very doubtful).

2. *Hippoporella* Canu, 1917, type-species *Lepralia hippopus* Smitt (= *Hippoporina*, type-species as used by Canu, 1917, *Lepralia hippopus* Smitt; and *Hippoponella*¹ Canu & Bassler, 1920, type-species *Lepralia hippopus* Smitt).

3. *Cleidochasma* Harmer, 1957, type-species *Gemellipora protrusa* Thornley (= *Hippoporina* Canu & Bassler, 1920, not Neviani, type-species *Lepralia porcellana* Busk).

The genus *Hippoporidra* is similar in character to *Cleidochasma*, but is here confined to species with cortical zooecia and a special type of interzooecial avicularium (see p. 22), which encrust gastropod shells.

2. HIPPOPORINA Neviani

Hippoporina Neviani, 1895 : 109. Harmer, 1957 : 977.

Hippodiplosia Canu : Osburn, 1952 : 338.

TYPE SPECIES. *Cellepora pertusa* Esper, 1796 : 149.

¹ I agree with Hastings (1930 : 724) and Osburn (1952 : 348) in regarding *Hippoponella* as an absolute synonym of *Hippoporella*. The second type-species of *Hippoporella* later chosen by Canu & Bassler (1920 : 377), *Hippoporella perforata*, was not included in the original introduction of the genus by Canu, but is congeneric with *H. hippopus*. Examination of Hincks's figured specimen of *Lepralia hippopus* (1880, pl. 33, figs. 8, 9, 1911.10.1.1134, Northumberland coast, Norman Coll.) which has all the characters of Smitt's description and figures, shows that, contrary to Canu & Bassler's diagnosis of *Hippoponella*, the ovicell is not closed by the operculum.

DIAGNOSIS. Zoarium encrusting. Zooecia with marginal pores and frontal pores, but with the area proximal to the orifice without pores; lateral and distal septula present. Orifice rounded with a pair of proximal lateral denticles forming a broad sinus, lateral peristome frequently slightly raised. Adventitious avicularia often present. Ovicell hyperstomial, porous, not closed by the operculum.

3. *Hippoporina pertusa* (Esper)

(Text-fig. 1A)

Cellepora pertusa Esper, 1796 : 149, pl. 10, figs. 1, 2, Recent, Mediterranean.

Hippodiplosia pertusa (Esper) Hastings, 1930 : 724, pl. 17, fig. 118, Galapagos, 4-15 fath., Gorgona, Panama. Osburn, 1952 : 340, pl. 40, figs. 5-8, S. California, 17 and 23 fath., Mexico and Galapagos.

MATERIAL. *Achimota* Coll. Stn. 47, Dredge haul No. 1, 4.i.51, 44 m., 14V. Stn. 117, Agassiz trawl No. 2, 5.iv.51, 64 m., 32O.

British Museum, Galapagos, 1929.4.26.142, "St. George" Coll. Pt. Vincente,

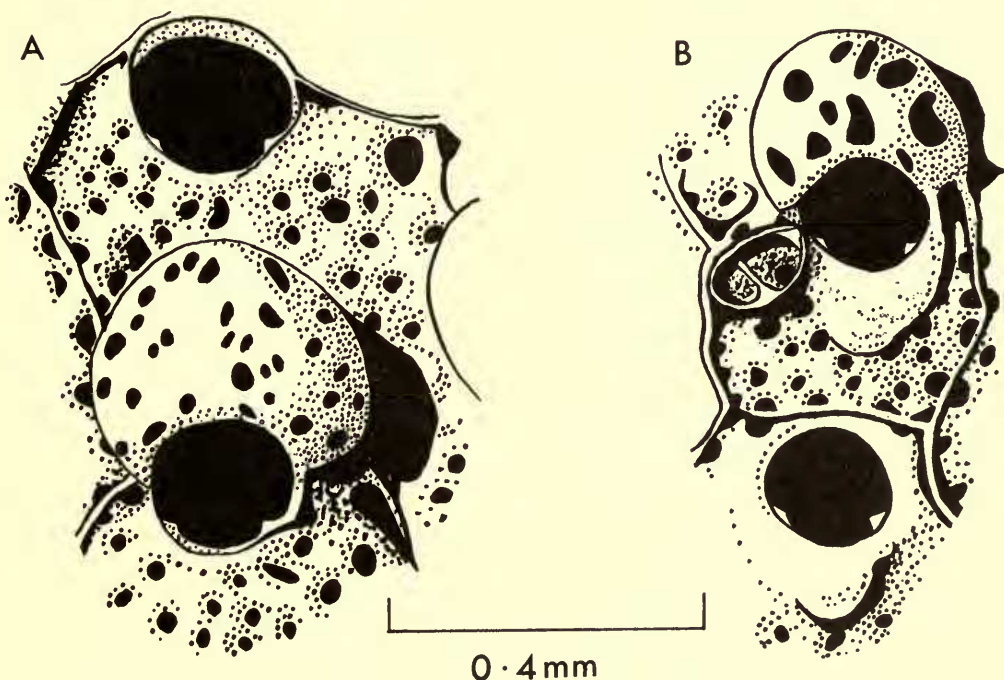


FIG. 1. *Hippoporina*, treated with eau de javelle. A. *H. pertusa*, zoecium and ovicell. Ghana, *Achimota* Coll. 14V. B. *H. americana*, zoecium and ovicell. Nigeria, 1959.2.20.4.

California, 65 ft., 1962.6.16.12, and Gulf of Mexico, 28° 58' N., 89° 9' W., 1961.11.2.35. Cheetham Coll., and many other specimens.

H. pertusa is not present in the "Calypso" or Marche-Marchad Collections.

DIAGNOSIS. *Hippoporina* with large, wide zooecia. Avicularia usually absent. Ovicells large, wide, pores frequently irregular.

Dimensions. Lz 0.70 mm., lz 0.60 mm., Lo 0.225 mm., lo 0.25 mm., Lov 0.35 mm., lov 0.50 mm.

No avicularia have been seen in any of the material examined. There are 3-4 lateral and 4-5 distal septula, the latter either scattered or in a row near the base of the distal wall.

H. pertusa has a wide geographical distribution extending from the Arctic to California, Florida and Suez (see Hastings, 1930, and Osburn, 1952). The west African specimens show little variation and are very similar to material from Galapagos and the Gulf of Mexico.

4. *Hippoporina americana* (Verrill)

(Text-fig. 1B)

Lepralia americana Verrill, 1875a : 415, pl. 7, fig. 4, Long Island Sound to Beverley, Mass., low-water to 30 fath. (not pl. 7, fig. 5 = *Cryptosula pallasiana* (Moll.), see Osburn, 1912 : 241).

Hippodiplosia americana (Verrill) Hastings, 1930 : 725, pl. 11, fig. 61, Balboa, Panama. Marcus 1937 : 101, pl. 20, figs. 54A, B, Brazil, Bahia de Santos, 10-20 m. Osburn, 1952 : 339, pl. 40, fig. 4, Mount Desert, Maine to N. Carolina, and Gulf of California to Costa Rica and Galapagos, 10-30 fath.

MATERIAL. *British Museum*, Lagos, Nigeria, 1959.2.18.2, Hill Coll. Port Harcourt, Nigeria, 1959.2.20.3, 4, 6 (on wood, gastropod and oyster shells respectively) ; Freetown, Sierra Leone, 1959.2.20.5 (on *Balanus amphitrite amphitrite* Darwin), Stubbings Coll. W. Africa, 1959.2.22.1, Frewen Coll. Balboa 4, Panama, 1929.4.26.147, "St. George" Coll. Santos, Brazil, 1948.2.16.29, Marcus Coll.

H. americana is not present in the "Calypso" Collections, the Marche-Marchad Collections, or the Achimota Collections.

DIAGNOSIS. Zoarium encrusting, sometimes plurilaminar. Peristome raised laterally, a large umbo frequently present proximally to the orifice. Avicularia often absent, when present with acute mandibles, directed centrally and distally, sub-rostral cavity swollen, with a complete bar.

Dimensions. Lz 0.38 mm., lz 0.30 mm., Lo 0.12 mm., lo 0.12 mm., Lm 0.05 mm., Lov 0.20 mm., lov 0.225 mm.

There are 3-4 lateral and 4 distal septula, about one-third of the way up the distal wall. The avicularia appear to arise secondarily, as in several cases the swollen sub-rostral chamber, when developing or broken, shows the frontal pores beneath it (see Text-fig. 1B). The bar supporting the mandible is slender, and is frequently broken even in slightly worn specimens. The ovicell is often very lightly calcified frontally, and the pores may be very large and irregular.

H. americana appears to be tolerant of a wide range of temperature and of slightly lowered salinity, the west African localities listed above being associated with river estuaries and saline lagoons.

5. *Hippoporina lacrimosa* sp. n.

(Text-fig. 2A)

HOLOTYPE. B.M. 1963.4.16.4, Achimota Coll., Stn. 47.

MATERIAL. *Marche-Marchad Coll. I*, 39E, Baie de Seminoles, Gorée, 8.xii.53, 38 m., growing over the convex surface of *Cupuladria* sp. 39A. *Coll. II*, 25F, S.W. du Cap. Manuel, Dakar, 20.ii.56, on *Cellepora* sp. 25D. *Achimota Coll.* Stn. 47, Dredge haul No. 1, 4.i.51, 44 m., 14S, Paratypes, and Stn. 48, as above, No. 2, 44 m., 46J. Stn. 110, Agassiz trawl, No. 1, 4.iv.51, 40 m., 48L. Stn. 111, as above, No. 2, 43 m., 49B. Stn. 112, as above, No. 3, 43 m., 60J. Stn. 132, as above, 2.v.51, 44 m., 40D and 42J.

H. lacrimosa is not present in the "Calypso" Collections.

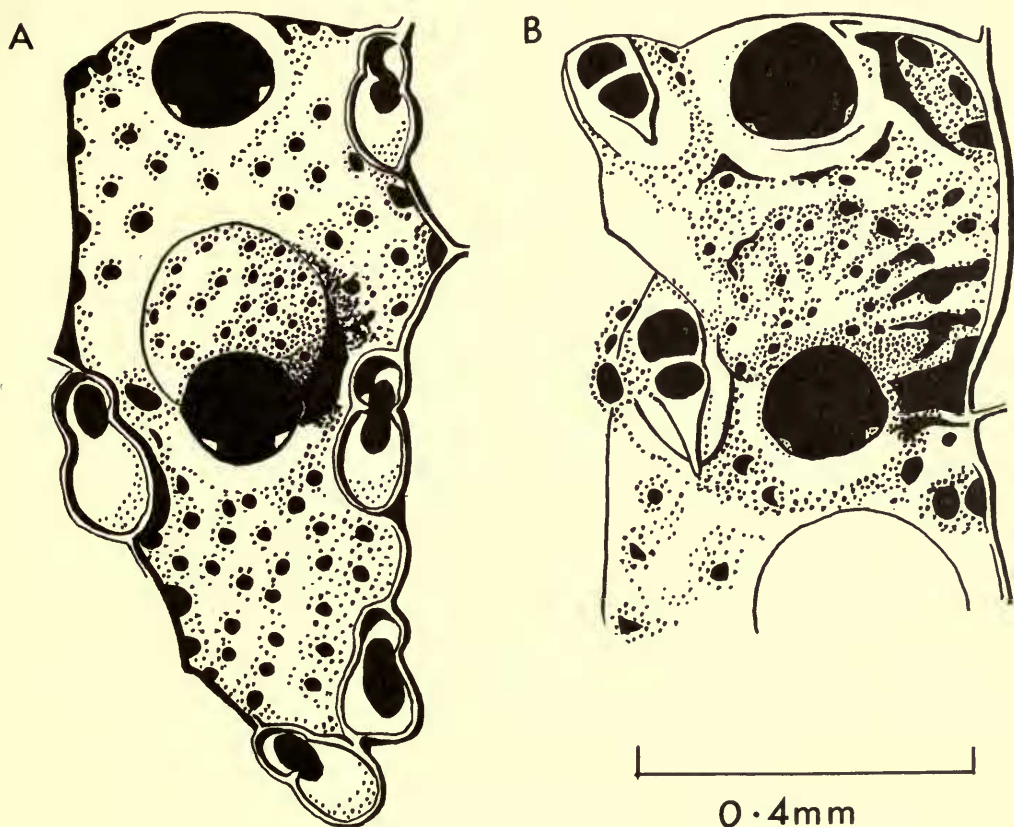


FIG. 2. *Hippoporina*, treated with eau de javelle. A. *H. lacrimosa*, zoecia with avicularia, and ovicell. Ghana, Achimota Coll. 14S. B. *H. acuta*, zoecium with avicularia, and ovicell. Ghana, Achimota Coll. 59D.

DIAGNOSIS. Zoarium encrusting. Small lateral peristomial tubercles and sub-oral umbo frequently present. Avicularia sometimes paired, sub-rostral cavity

slightly swollen, with a delicate bar. Rostrum and mandible broadly spatulate, directed proximally. Ovicell porous, prominent, occasionally extending over two distal zooecia.

Dimensions. Lz 0.50 mm., lz 0.35 mm., Lo 0.11 mm., lo 0.125 mm., Lm 0.10 mm., Lov 0.20 mm., lov 0.27 mm.

The distal communication pores of *H. lacrimosa* differ from those of the other species as they are so low on the wall that they may pass through the angle between the distal and basal walls. In these cases, secondary calcification round the pores produces an appearance very similar to that of dietellae.

6. *Hippoporina acuta* sp. n.

(Text-fig. 2B)

HOLOTYPE. B.M. 1963.4.16.5, Achimota Coll. Stn. 35.

MATERIAL. *Achimota Coll.* Stn. 35, Dredge No. 1, 21.xii.50, 37 mm., 59D (on *Jullienella foetida*), Paratypes. Stn. X, Axim, Hospital reef, 7.i.51, 68J (with 68E *Hippoporidra littoralis* see p. 28).

"*Calypso*" Coll. I. Stn. 114, devant baie 8. Antonio, 8.vii.56, 50 m., C 15 O.

H. acuta is not present in the "*Calypso*" Collection II from the Cape Verde Islands, or in the Marche-Marchad Collections.

DIAGNOSIS. Zoarium encrusting. Zooecia similar to those of *H. lacrimosa*. Avicularia sometimes paired, lateral to the orifice, sub-rostral cavity very swollen; with a complete bar, directed proximally and centrally. Mandible triangular, acute, curved. Ovicell porous, less prominent than in *H. lacrimosa*.

Dimensions. Lz 0.40 mm., lz 0.30 mm., Lo 0.11 mm., lo 0.12 mm., Lm 0.10 mm., Lov 0.20 mm., lov 0.32 mm.

H. acuta resembles the figure of *Hippothoa reversa* (Verrill 1875b : 41, pl. 3, fig. 1, Gay Head, New England), but differs in the inward orientation of the avicularia. *H. acuta* and *H. lacrimosa* are very similar but no form intermediate to the two very different types of avicularia has been seen. The two species also differ in the position of the distal septula, which in *H. acuta* are like those of *H. americana*; and in the wider, less prominent ovicells of *H. acuta*. The oral denticles of *H. acuta* are slightly more proximal in position than those of *H. lacrimosa*.

Material of both species in the Achimota Coll. encrusts the Foraminiferan, *Jullienella foetida* Schlumberger, and thus belongs to the silty-sand community of Buchanan (1958) and Bassindale (1961).

7. *HIPPOPORELLA* Canu

Hippoporella Canu, 1917 : 36. Osburn, 1952 : 348.

Hippoponella Canu & Bassler, 1920 : 379.

TYPE-SPECIES. *Lepralia hippopus* Smitt, 1868 : 20, 127, pl. 26, figs. 99-105, Spitzbergen and Finmark.

DIAGNOSIS. Zooecia small, frontal pores rare. Orifice with oral spines and a pair of small proximal-lateral denticles, proximal margin slightly curved. Small

adventitious avicularia and occasional vicarious avicularia present. Ovicells imperforate, not closed by operculum.

8. *Hippoporella gorgonensis* Hastings

(Pl. I, fig. 1, Text-fig. 3A)

Hippoporella gorgonensis Hastings, 1930 : 723, pl. 12, figs. 62-72, pl. 17, figs. 119, 121, Galapagos Coiba, and Gorgona, shore to 15 fath. Marcus, 1937 : 99, pl. 19, figs. 53A, B, Brazil, Bahia de Santos, 20 m. Soule, 1961 : 20, Gulf of California, 1-17.5 fath.

HOLOTYPE. B.M. 1929.4.26.137, Gorgona.

MATERIAL. *Achimota Coll.* Stn. 35, dredge haul No. 1, 21.xii.50, 37 m., 59O. Stn. 72, as above, No. 3, 24.i.51, 38 m., 61O. Stn. 110, Agassiz trawl No. 1, 4.iv.51, 40 m., 48S. Stn. 133, as above, No. 3, 2.v.51, 51 m., 45U. Stn. K, on trawl debris, 1 mile offshore, 2 miles beyond Densu, 2.iii.49, 36G and 44H.

British Museum, Galapagos, 1929.4.26.130, 131, 134-136, 139, 141. Gorgona, 1929.4.26.132, 133, 137. Coiba, 1929.4.26.161. Taboga, 1929.4.26.138. Jicarón, 1929.4.26.140, "St. George" Coll. Santos Brazil, 1948.2.16.30 and Guariyá, Brazil, 1948.2.16.78, Marcus Coll.

H. gorgonensis is not present in the "Calypso" or the Marche-Marchad Collections.

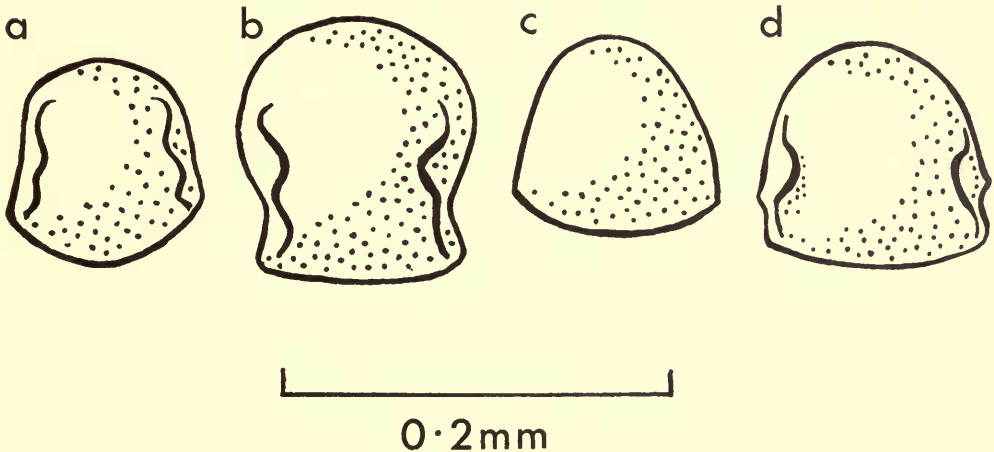


FIG. 3. Opercula in *Hippoporella*. A. *H. gorgonensis*, Ghana, Achimota Coll. 44H. B. *H. hippopus*, Kola peninsula, 1899.7.1.1430. C. *H. multidentata*, Siboga Coll. Sulu archipelago, 62O. D. *H. pusilla*, Cape Verde Islands, 1926.10.1.19.

DIAGNOSIS. Zoarium encrusting, plurilaminar. Zooecia with marginal pores but no frontal pores, and 2-4 lateral and distal septula, the latter low on the distal wall. Orifice with 4 oral spines and a pair of minute proximal-lateral denticles, proximal border nearly straight ; surrounded by lateral and proximal umbos. Avicularia adventitious, frequent, variable, usually paired, one each side of the orifice, occasionally larger, variously orientated. Ovicell hyperstomial, not porous, frequently with a spiked umbo on the front.

Dimensions. Lz 0.30 mm., lz 0.25 mm., Lo 0.08 mm., lo 0.08 mm., Lm 0.04 mm., Lov 0.12 mm., lov 0.20 mm.

The young zooecia at the growing edge may be without avicularia or umbos surrounding the orifice, they consequently have a very different appearance to those in older parts of the colony (see Hastings, 1930 : 723). The opercula of the west African specimens appear to be of the type with curved lateral sclerites figured by Hastings (1930, pl. 12, fig. 72); they are very similar to those of *H. hippopus* (Kola Peninsula, 1899.7.1.1430, Busk. Coll.). *H. gorgonensis* is very similar to specimens of *H. multidentata* (see Harmer, 1957 : 1090, pl. 73, figs. 9-12), from Ceylon (1936.12.30.41A) and India (1936.12.30.117), but opercula of *H. multidentata* from the Sulu Archipelago (Siboga Coll. 620), do not have any lateral sclerites (see Text-fig. 3C). *H. gorgonensis* has 4 oral spines and *H. multidentata* has 6. When an ovicell is present the number of spines is reduced to 2 in *H. gorgonensis* and 4 in *H. multidentata*. Avicularia are present on the ovicelled zooecia of *H. gorgonensis*, but absent in *H. multidentata*. Harmer noted that the ovicells of *H. gorgonensis* had a "more complete frontal wall" than those of *H. multidentata*.

H. gorgonensis has not been previously reported from the eastern Atlantic.

9. *Hippoporella pusilla* (Smitt)

(Text-fig. 3D)

Discopora albirostris forma *pusilla* Smitt, 1873 : 70, pl. 12, fig. 233, Florida, 9-60 fath.

Cellepora sexspinosus Waters, 1899, pl. 3, fig. 12, Madeira (no description). Norman, 1909 : 311.

Lepralia watersi Calvet, 1906b : 216 ; 1907 : 412, pl. 27, fig. 11, Cape Verde Islands, 20-25 m.

Holoporella pusilla (Smitt) Waters, 1918a : 22, pl. 2, figs. 7-9, Cape Verde Islands, 10 fath.

MATERIAL. "Calypto" Coll. II. Stn. 26, 15° 16' 30" N., 23° 47' 31" W., 18.xi.59, 50-65 m., île Sao Tiago, C65I. Stn. 42, Ponto do Anciao, 20.xi.59, 15-30 and 60 m., C104E. Stn. 75, 16° 04' 20" N., 22° 58' 10" W., 25.xi.59, 45 m., C106F. Stn. 86, 16° 36' 20" N., 22° 52' 05" W., 26.xi.59, 25 m., C71E.

British Museum, Cape Verde Islands, 1926.10.1.19, Waters Coll.

Museo do Seminario, Funchal. 1 slide, Type of *C. sexspinosus* Waters.

Hippoporella pusilla is not represented in the Marche-Marchad or Achimota Collections.

DIAGNOSIS. Zoarium encrusting, plurilaminar. Zooecia larger than those of *H. gorgonensis* or *H. multidentata*. Orifice lepralioid with a large sub-oral umbo, a pair of distinct oral denticles and 6 long oral spines. One or two small avicularia near the orifice, with pointed mandibles, directed distally. Occasionally other adventitious avicularia present. Ovicell small, finely tuberculate, raised above the orifice and wide open frontally.

Dimensions. Lz 0.45 mm., lz 0.30 mm., Lo 0.10 mm., lo 0.10 mm., Lm 0.06 mm., Lov 0.10 mm., lov 0.15 mm.

Calvet tentatively suggested that his *L. watersi* was synonymous with *C. sexspinosus*, and Waters, in describing material from the Cape Verde Islands stated that *L. watersi* was identical with both *C. sexspinosus* and *H. pusilla*. The type of *C. sexspinosus* is a very young colony without ovicells, but shows the long oral spines. Harmer

(1957 : 1097) considered that the ovicells of *H. pusilla* were unlike those normally found in *Hippoporella*, but the ovicells of Waters's Cape Verde Islands specimens (1926.10.1.19) are similar to those of *H. multidentata*. They are small and very open frontally, and significantly narrower than those of *H. gorgonensis*. In ovicelled zooecia, only one pair of spines is present, thus differing from *H. multidentata*. The large umbo below the orifice is not accompanied by lateral processes, as in *H. gorgonensis*. *H. pusilla* differs from both *H. gorgonensis* and *H. multidentata* in the form of the operculum and Hastings (1930 : 724) remarked on the differences between the opercula of these two species. Those of *H. pusilla* are the larger, with a nearly straight proximal edge, and with a pair of very short lateral sclerites, ending distally in strong protuberances which articulate with the oral denticles. These protuberances give the operculum the characteristic notched appearance figured by Waters (1918a, pl. 2, fig. 8), and see Text-fig. 3D.

10. *CLEIDOCHASMA* Harmer

Cleidochasma Harmer, 1957 : 1038. Soule, 1961 : 18.

TYPE SPECIES. *Gemellipora protrusa* Thornley, 1905 : 119, pl. 7, Ceylon.

DIAGNOSIS. Zoarium plurilaminar, encrusting or erect. Orifice cleithridiate, with a pair of well-developed condyles. Oral spines frequently present.¹ Marginal and a few frontal pores present, lateral and distal uniporous septula, or multiporous rosette plates or dietellae present. Interzooecial and adventitious avicularia present. Ovicell hyperstomial, with a frontal area, not closed by the operculum.

11. *Cleidochasma porcellanum* (Busk)

(Pl. 1, fig. 4, Pl. 2, figs. 1, 2, Text-figs. 4A-E)

Lepralia porcellana Busk, 1860 : 283, pl. 31, fig. 3, Madeira.

Lepralia cleidostoma Smitt, 1873 : 62, pl. 11, figs. 217-219, Florida, 30-120 fath.

Hippoporina porcellana (Busk) Hastings, 1930 : 722, Taboga, Gorgona, Galapagos, 1-30 fath., synonymy. Sakakura, 1935 : 23, pl. 4, fig. 6, Pleistocene, Japan. Marcus, 1937 : 96, pl. 19, fig. 51, Brazil, Santos, 20 m.; 1938 : 217, text-fig. 17, St. Helena, 27-55 m., synonymy and distribution. Osburn, 1952 : 344, pl. 41, figs. 1-3, southern California to Callao, Peru.

Hippoporina simplex Canu & Bassler, 1930 b : 49, pl. 6, figs. 3, 6, Tunisia.

Hippoporina bassleri Calvet, 1931 : 84, pl. 2, figs. 33A-C, Cape Verde Islands.

Cleidochasma bassleri (Calvet) Harmer, 1957 : 1042, pl. 71, figs. 5, 16, East Indies, synonymy and distribution.

Cleidochasma porcellana [sic] (Busk) Soule, 1961 : 18, Gulf of California, 1-45 fath.

LECTOTYPE. Chosen here, B.M. 1899.7.1.1726, Madeira, Busk. Coll.

LECTOPARATYPES. 1899.7.1.1727, 1728.

MATERIAL. "Calyпсо" Coll. I. Stn. 3, 13° 1' N., 17° 24' W., 15.v.56, 51-55 m., C54F. Stn. 25, 4° 36' 5" N., 1° 31' W., 24.v.56, 50 m., C10H. Stn. 26, 4° 37' N., 0° 50' W., 24.v.56, 100-90 m., C17B (on shell). Stn. 45, 0° 25' N., 9° 0' E., 8.vi.56, 73 m., C48E on 48A and D, *Discoporella* spp., and C55C on 55F, *C. brancoense*, and 55E, *Hippoporidra senegambiensis*. Stn. 110, off Principe, 7.vii.56, C9L (on shell).

¹ Oral spines are apparently absent in *C. protrusum* and *C. rotundorum*, but are present in the other species described here.

Stn. 114, devant B. de Sao Antonio, 8.vii.56, 50 m., C15B. Stn. P2, entre Pte. da Mina et I. S. Ana, 4.v.56, 8-10 m., C8H (on shell). Stn. P3, devant Cais de S. Ana, 26.vi.56, 11 m., C19A (on shell). Coll. II. Stn. 24, 15° 16' 34" N., 23° 47' 44" W., 55-60 m., 95E, 100E. Stn. 26, 15° 16' 30" N., 23° 47' 31" W., 50-65 m., 121N, 125N. Stn. 65, 15° 37' N., 25° 69' W., 150-120 m., 67D.

Marche-Marchad Coll. I. Cap Matakong, Guinée Ise., 4 I, on shell with *C. oranense* and other species.

Achimota Coll. I. Stn. 126, Agassiz trawl No. 3, 12.iv.51, 16 m., 37G (on shell). Stn. K, on trawl debris, 1 mile offshore, 2 miles W. of Densu R., 2.iii.49, 4 fath., 361 and 44E (on shell).

Coll. II. Chorkor, seine net, 1.ii.50, 22N (on worm tubes and shell).

British Museum, Madeira, 1899.7.1.1726, 1727, 1728, 2352, 2353, Busk. Coll. Madeira, 1910.11.1.1112A & C (with *C. contractum*), 1115; Santa Cruz, 115 fath., 1910.11.1.1116; Grenada, 170 fath., 1910.11.1.1113; Havana, 1910.11.1.1114A, Norman Coll. John Adams Bank, off Brazil, 1899.7.1.3347, Busk. Coll. Bahia, 1899.5.1.800, Hincks Coll. Gulf of Mexico, 1932.3.7.87, Canu & Bassler Coll. Gulf of Mexico, 1959.8.20.9, Lagaaij Coll. South pass of Mississippi R., 28° 58' N., 89° 8' W., 1961.11.2.25, and Campeche Bank, 1961.11.2.22, 23, 24, Cheetham Coll. Gorgona, 1929.4.26.126, "St. George" Coll. Galapagos, 1933.12.10.26, Canu & Bassler Coll. Tizard reef, China Sea, 1889.8.21.65. Alexandria, 1963.8.2.37, O'Donoghue Coll. Ceylon, 1936.12.30.34A, Thornely Coll. Philippines, 1931.12.30.114, 115, Canu & Bassler Coll. Siboga Coll., all specimens listed by Harmer (1957: 1042).

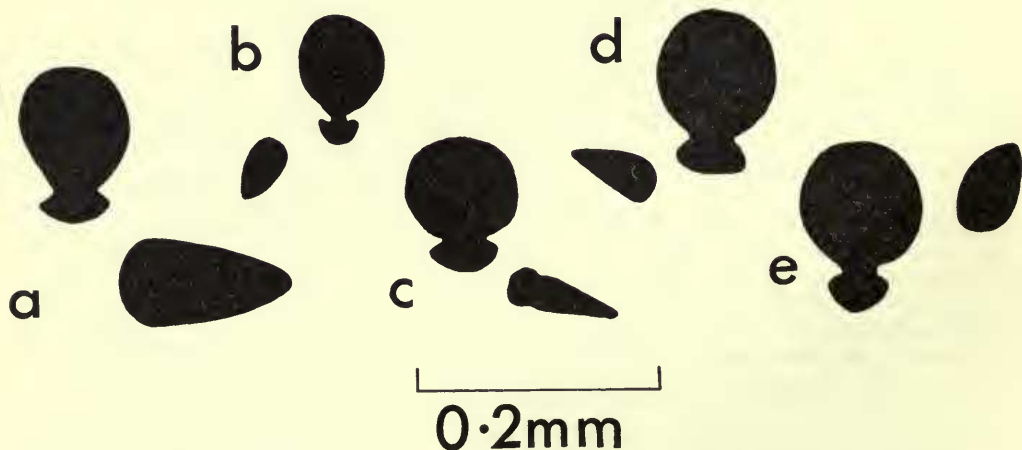


FIG. 4. Variation in shape of orifice and position of avicularia in *Cleidochasma porcellanum*.

A. Campeche Bank, Gulf of Mexico, 1962.11.2.22. B. Ceylon, 1936.12.30.34A. C. Bay of Biafra, "Calypso" Coll. C55C. D. Madeira, 1899.7.1.1726. E. Tizard Reef, 1889.8.21.65.

Museu do Seminario, Funchal, 1 slide in Waters Collection.

Naturhistoriska Riksmuseet, Stockholm. No. 284, W. of Tortugas, 16.i.1869, 42 fath. ? Type of *Lepralia cleidostoma*.

DIAGNOSIS. Zoarium encrusting, plurilaminar. Zooecia with marginal pores and porcellanous, smooth or mammillate frontal, 3-4 lateral and distal septula. Orifice with 3 oral spines, cleithridiate, very variable in shape. Operculum with 2 lateral sclerites. Avicularia frequently paired, with a complete bar, situated at or below the level of the sinus, directed outwards and upwards, mandible acute. Ovicell with a small area on the proximal border.

Dimensions. Lz 0.45 mm., lz 0.30 mm., Lo 0.14 mm., lo 0.11 mm., Lop 0.14 mm., lop 0.10 mm., Lav. 0.09 mm., Lm 0.05 mm., Lov 0.15 mm., lov 0.19 mm.

The appearance of *C. porcellanum* varies considerably with the nature of the frontal wall, the position, dimensions and proportions of the orifice, the size and position of the avicularia, and the age and degree of calcification of the ovicells.

The frontal wall was described by Busk as "uneven, bossed, granular, polished, porcellanous". Busk's colonies show two types of frontal, although the other zooecial characters are the same. In 1899.7.1.1726 the frontal is hyaline and smooth, in 1899.7.1.1727 and 1728 it is mammillated, and greatly resembles the figure of *H. bassleri* given by Calvet. Mammillate frontals are also present in 1961.11.2.25, Gulf of Mexico, 1899.7.1.2352 and 2353, Madeira, and 1889.8.21.65, Tizard Reef, but in the majority of specimens the zooecia are smooth.

The variation in the shape of the orifice is very great, and several forms have been recognized. Some orifices are elongated, with a small triangular sinus, others are rounded with a wide, shallow sinus (see Text-figs. 4A-E). However, these extremes may occur within one zoarium (e.g. 1936.12.30.34A), and intermediate forms exist throughout the material. Furthermore, there appears to be no positive correlation of orifice type with locality or depth. *C. porcellanum* thus differs from the 3 species of *Hippoporidra* described below (pp. 28-32), where the different forms of the orifice are exclusive and are correlated with other distinguishing characters.

The orifice may be surrounded by one proximal and a pair of lateral raised umbos (1899.7.1.1728 and Achimota Coll. 22N). Hastings (1930 : 722) expressed doubt as to the validity of the position of the orifice with relation to the distal wall as a specific character. The orifice is near the distal edge of the zooecium in Siboga Coll., Japan, 53 fath., Owston Coll. 2X ; 1911.10.1.1112, Madeira ; 1899.5.1.800, Bahia ; and 1931.12.30.114, Philippines. It is appreciably removed from the distal edge in Siboga Coll., Torres Straits, Haddon Coll. 173 ; Achimota Coll. 44E ; 1936.12.30.34, Ceylon and 1933.12.10.26, Galapagos. Waters (1899 : 10, pl. 3, figs. 16, 17) mentioned the large variation in the opercula, which may also be seen in the figures of Smitt (1873, pl. 11, figs. 217, 218, 219) and Canu & Bassler (1920, text-fig. 114B-E ; 1929, text-fig. 132B-H).

The size and position of the avicularia varies considerably (see Text-fig. 4A-E). In many specimens (or even parts of one colony) they are minute or absent, in others they are larger, with elongated triangular mandibles, which may be curved or flat. Their position varies, from one close to the orifice to one near the borders of the zooecium, and from level with the poster to below the sinus, sometimes within one specimen (e.g. 1936.13.30.34A pt., Ceylon). Occasionally some zooecia have a

large avicularium, with a mandible similar to that of *C. laterale* Harmer (1957 : 1044, pl. 71, figs. 9-11), e.g. 1911.10.1.1116 Santa Cruz, and 1961.11.2.22, Campeche Bank.

Near the growing edge the ovicells are conspicuous and hyaline, with a distinct, thinner, frontal area, and frequently with paired channels on the proximal lateral border which may mark the former position of the oral spines. At this stage, the ovicell may be faintly striated, with lines of slightly thicker calcification below the surface which reflect light differentially. Later the surface becomes finely tuberculate and finally the ovicell is progressively immersed by heavy secondary calcification. Striated ovicells were figured by Smitt (1873, pl. 11, fig. 217) who, however, also showed an older, immersed ovicell (fig. 218). Smitt's specimen has been re-examined and a photograph of one of the young striated ovicells is given on pl. 2, fig. 1 for comparison with fig. 2. Striated ovicells are present in the following specimens :—Achimota Coll. 44E ; "Calypso" Coll. II C125N ; 1911.10.1.1112, Madeira ; 1899.9.7.1.3347, John Adams Bank ; and Siboga Coll., Ceylon, Thornely Coll. 55.

Norman (1909 : 305) first equated *L. cleidostoma* Smitt with *L. porcellana* Busk, and Calvet (1931 : 84) stated that the avicularia of *H. bassleri* were similar to those of the other two species and remarked "Ce sont des formes voisines". Harmer (1957 : 1042) established a very wide range of variation for *C. bassleri*, but all the Pacific and Indian Ocean records he included had been placed in *H. porcellana* by Marcus (1938 : 217) who distinguished *H. bassleri* by its more constricted operculum and regularly mammillate frontal. Neither of these distinctions appears now to be specific. *C. bassleri* was originally described from the Cape Verde Islands and *C. porcellanum* from Madeira, and thus both species also have similar eastern-Atlantic type-localities. The conclusion is inevitable that *C. porcellanum* (Busk) varies in a similar degree to, and indeed includes, *C. bassleri* (Calvet).

The distal septula in *C. porcellanum* are small and slit-like, close to the base of the wall. The basal lamina of the growing edge is frequently ridged vertically on either side of each pore, forming a chamber. This development may be seen particularly well in "Calypso" Coll. C95E. Thus the distal "chambered pore" of *C. porcellanum* resembles both the sunken rosette plates of *C. protrusum* and the true dietellae of *C. contractum*. A similar variation in position and relationships of the distal pores is found in *Hippoporina* (see p. 8).

12. *Cleidochasma contractum* (Waters)

(Text-fig. 5A)

Lepralia contracta Waters, 1899 : 11, pl. 3, figs. 4-6, Madeira. Norman, 1909 : 306, pl. 41, figs. 5, 6, Madeira.

Perigastrella contracta (Waters): Hastings, 1930 : 722, pl. 11, fig. 60, Galapagos, 10-30 fath., Gorgona. Marcus, 1937 : 98, pl. 20, figs. 52A, B, Brazil, Santos, 20 m., synonymy and discussion.

Hippoporina contracta (Waters) : Osburn, 1940 : 428 ; 1952 : 346, pl. 41, figs. 4-5, Ecuador to Gulf of California. Marcus, 1955 : 298, Espirito Santo, 35 m.

Cleidochasma contracta [sic] (Waters) Soule, 1961 : 19, Gulf of California, 1-40 fath.

The type-material of *C. contractum* is preserved in the Museo do Seminario, Funchal, Madeira (see Norman, 1909 : 306).

MATERIAL. "*Calyпсо*" Coll. I. Stn. 4, 12° 55' N., 17° 33' W., 16.v.56, 65-75 m., C3C (on sandy worm-tubes with *Rhynchozoon* sp.). Stn. 17, 5° N., 5° 28' 30" W., 21.v.56, 27 m., C56E (on *Jullienella foetida*). Stn. 110, 1° 2' 45" N., 7° 17' 34" E., 7.vii.56, 25-40 m., G. Frère N.E., C32A (on stem of alga). Stn. 114, devant B. de Sao Antonio, 8.vii.56, C15C. Stn. T5, à l' E. Ste Diego, 7.v.56, nunes à pied, C26A. Coll. II. Stn. 14, 14° 53' 43" N., 23° 31' 24" W., 17.xi.59, 25-30 m., C68G. Stn. 24, 15° 16' 34" N., 23° 47' 44" W., 18.xi.59, 55-60 m., C91H, C97D, and C98D. Stn. 25, 15° 16' 30" N., 23° 47' 31" W., 18.xi.59, 50-65 m., C121D.

Marche-Marchad Coll. II. 3A, no information (on *Murex* shell).

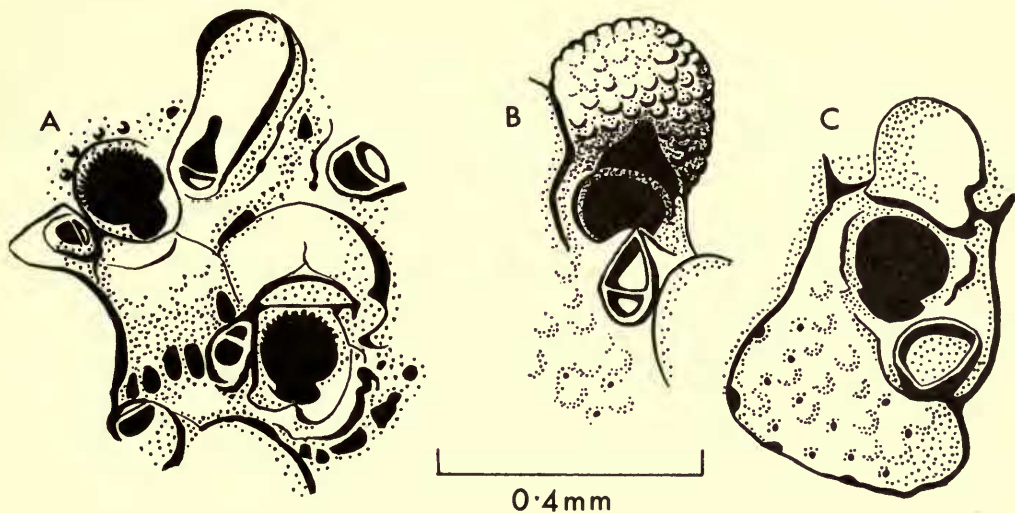


FIG. 5. *Cleidochasma*, treated with eau de javelle. A. *C. contractum*, zooecia, with large spatulate, and small avicularia, and ovicell, Ghana, Achimota Coll., C, F. B, c. *C. rotundorum*, B. Ovicell. c. Zooecium with basal wall of broken ovicell, Madeira, 1911.10.1.1664.

Achimota Coll. I (all specimens on *J. foetida*). Stn. 35, dredge haul No. 1, 21.xii.50, 37 m., 59B. Stn. 45, as above, No. 5, 22.i.51, 22 m., 62K. Stn. 47, as above, No. 1, 4.i.51, 44 m., 14U. Stn. 48, as above, No. 2, 46L. Stn. 72, as above, No. 3, 24.i.51, 38 m., 61I. Stn. 73, as above, No. 4, 41 m., 58G. Stn. 110, Agassiz trawl, No. 1, 4.iv.51, 40 m., 48N. Stn. 111, as above, No. 2, 43 m., 49D. Stn. 112, as above, No. 3, 60L. Stn. 131, as above, No. 1, 2.v.51, 37 m., 41M, 43M. Stn. 132, as above, No. 2, 44 m., 40F and 42L. Stn. 133, as above, No. 3, 51 m., 45N. Specimen C, F, Achimota.

Coll. II. 23Q, Seine net, Chorkor shore, 12.v.50.

British Museum, Madeira, 1911.10.1.1112A (with *C. porcellanum*), 1156 and 1160 (on clinker), and Havana, 80 fath., 1911.10.1.1114, Norman Coll. St. Vincent,

Kingstown Harbour, 1931.5.2.5 pt., Totton Coll. Galapagos, 1929.4.26.189, "St. George" Coll. Campeche Bank, 24° 4' N., 91° 50' W., 26 fath., 1961.11.2.16, and S. Pass of Mississippi R. 28° 4' N., 58° N., 89° 9' W., 1961.11.2.15, Cheetham Coll. Mauritius, 1934.10.6.24.

Museo do Seminario, Funchal, 1 slide, Type of *L. contracta* Waters.

DIAGNOSIS. Zoarium encrusting, plurilaminar. Zooecia with marginal pores only, dietellae present. Orifice with 4–8 oral spines and a strongly beaded rim, with a pair of strong denticles marking a rounded sinus. Avicularia with a bar, very variable in size and occurrence, occasionally absent from areas of the colony. Usually one or two rounded avicularia, or one large sub-oral or lateral avicularium, with a spatulate mandible. Ovicells hyperstomial with a large semi-circular area on the front.

Dimensions. Lz 0.41 mm., lz 0.33 mm., Lo 0.11 mm., lo 0.10 mm., Lm 0.03–0.23 mm., Lov 0.18 mm., lov 0.20 mm.

The type-species of *Perigastrella* Canu & Bassler (1917 : 68) is "*Lepralia labiata* Boeck, 1861". Boeck (1862 : 49–50) did not describe this species, which was introduced by Smitt (1868 : 27, 175). Osburn (1940 : 428) gave reasons for separating *L. contracta* from *Perigastrella*, and placed the species in *Hippoporina* (Canu & Bassler not Neviani, see p. 4). Harmer (1957 : 823 and 1025) emphasized that *L. labiata* and *L. contracta* were not congeneric.

The variability in appearance of *C. contractum* is principally dependent upon the development of the avicularia. At the growing edge of a colony the zooecia frequently have only a small sub-oral umbo, and avicularia are absent, as Waters noted (1899 : 11). The lateral peristome is sometimes slightly raised laterally. Where conditions of growth are crowded, or where the colony is plurilaminar and secondary calcification has taken place, the orifices are immersed and there is a large number of avicularia, some of which may obscure the orifice altogether. The specimens from Havana (1911.10.1.1114) and Mauritius (1934.10.6.24) have a large avicularium directed distally alongside the orifice in the same manner as that of the specimen from Madeira figured by Waters (1899, pl. 3, fig. 4). Examination of the figured slide shows that this type of avicularium is associated only with fertile zooecia. Specimens from the Achimota Coll. have a large avicularium either lying across the proximal edge of the orifice or pointed distal-laterally, whereas many of those from the Cape Verde Islands ("Calypso" Coll. II) have only small rounded avicularia and a sub-oral umbo. However variable the superficial appearance of the colonies, *C. contractum* may always be recognized by the beading round the distal edge of the orifice, and by the large semicircular area on the front of the ovicell.

The occurrence of distinct dietellae in *C. contractum* was noted by Hastings (1930 : 739, expl. of pl. 11, fig. 60). The communications in *Cleidochasma* are very variable ; in *C. protrusum* (Thornely), (Ceylon, 1906.12.3.11 and 1936.12.30.63, Thornely Coll.), and *C. areolatum* (Canu & Bassler), (Philippines, 1931.12.30.106, 107, Canu & Bassler Coll.), they consist distally of a pair of large multiporous rosette plates, surrounded by ridges of calcification, similar to those of *C. oranense* and

C. brancoense (see p. 19) ; but in *C. porcellanum* they approach a chambered structure like that of *C. contractum* (see p. 14).

The number of oral spines in *C. contractum* is variable. Four are present in most of the material from west Africa and the Gulf of Mexico. The zooecia of the Galapagos, Kingstown harbour and Mauritius specimens, however, have 5–8 spines ; while Marcus (1937) figured 7 spines in Brazilian, and Norman (1909) 6–7 in Madeiran, material.

Whereas colonies from the Cape Verde Islands, Senegal and the Bay of Biafra encrust stones and shells, those from the coast of Ghana almost exclusively encrust the Foraminiferan *Jullienella foetida* (see p. 8). Distribution. Madeira, Cape Verde Islands, west Africa, Brazil, West Indies, Tortugas, Florida, Long Island Sound, Woods Hole, Panama, California, Colombia, Galapagos.

13. *Cleidochasma oranense* (Waters)

(Pl. 2, fig. 3, Pl. 3, fig. 2, Text-fig. 6A–B)

Lepralia oranensis Waters, 1918b : 101, pl. 12, figs. 11–13, Oran, " zone coralligène " 54 fath.;

Petit Tahou, Liberia. Canu & Bassler, 1928b : 33, pl. 3, figs. 8–10, Cap Blanc, 20–30 m.

Gemelliporella oranensis (Waters) Barroso, 1925 : 177, text-figs. 1, 2, Oran, 62–65 " brazas " (= fathoms).

LECTOTYPE, chosen here, Manchester Museum, slide from Oran, 54 fath., Waters Collection.

MATERIAL (specimens with ovicells* marked with an asterisk). "*Calypso*" Coll. I. Stn. 1, 21° 05' N, 17° 14' W, 10.v.56, 43–45 m., C51D* (on barnacle), and C52C (on shells and *Schizzamina* sp., a Foraminiferan).

Marche-Marchad Coll. I. Konakrey, Guinée Ise., 1D*, 21*. Sud de Gorée, 24.ii.53, 40–41 m., 11E. Cap Matakong, 4A (on *Pecten* shell, encrusting base and erect branches). S.W. Madeleines, 15.ix.53, 48 m., 25A*, and 9.i.54, 45–46 m., 27C*. Sud de presque l'île de Cap Vert, 18.ii.54, 95 m., 33D.

Coll. II. S.E. des Madeleines, 15.ix.53, 48 m., 2A. Baie de Gorée, 50–100 m., 7G. Large de Gorée, 5.vii.55, 50 m., 8D, 27E. S.W. Cap Manuel, 20.ii.56, 50 m., 13A. Au large de Saloum, 9.iii.55, 50 m., 17C. S. Baie de Gorée, 18.ii.54, 95 m., 30A. S.W. Madeleines, 9.i.54, 47.5 m., 31O* (unilaminar erect expansions), and 15.ix.53, 48 m., 40C*.

Coll. III. Either S.W. Madeleines, 15.ix.53, 48 m., or S. de Gorée, 13.xi.53, 34–37 m., 16A. Large de Gorée, 50 m., Stn. 55.vii.5A, 18C. S.W. Cap Manuel 50 m., Stn. 56.iii.20D, 26A ; and Stn. 56.ii.20B, 25B. " Gérard Fréca " Dragage 1, 18.ii.54, 23D ; Dr. 5, 27B. No information, 21C, 24C.

Achimota Coll. I. Stn. 47, Dredge haul No. 1, 4.i.57, 44 m., 14E. Stn. 62, as above, No. 2, 18.i.51, 30 m., 87IB. Stn. 117, Agassiz trawl No. 2, 5.iv.51, 64 m., 32D, & Coll. II, 13A. Stn. 132, as above, 2.v.51, 44 m., 50A.

Coll. II. 23R, Chorkor shore, seine net, 12.v.50 (worn).

British Museum, Cap Blanco, west Africa, 11–35 fath., 1921.5.23.7 and 1927.10.30.11, Metzelaar Coll. west Africa, 1959.2.16.1.

Manchester Museum. Waters Coll. 5 slides from Oran, the lectotype, labelled

"material sent by Canu", is probably the specimen figured by Waters on pl. 12, fig. 11. 2 slides from Jullien Coll., Petit Tahou, Liberia.

C. oranense is not present in the "Calypso" Collection II, from the Cape Verde Islands (see p. 20).

DIAGNOSIS. Zoarium with an encrusting base and erect branches composed of superposed layers of zooecia. Zooecia with large marginal pores and occasional small frontal pores. Orifice with 4 oral spines, cleithridiate, with large condyles, proximal edge of anter straight. Operculum globose distally with a pair of lateral sclerites. 2 distal and 1-2 lateral rosette plates. Avicularia large, interzooecial, numerous, directed distally, with an acute rostrum and complete bar. Mandibles long and curved. Ovicells hyperstomial, but immersed, eventually almost hidden by secondary calcification, with a small area on the proximal frontal border. Polypide with 15 tentacles (Barroso).

Dimensions. Lz 0.50 mm., lz 0.30 mm., Lo 0.19 mm., lo 0.13 mm., Lav 0.40 mm., Lm 0.35 mm., Lov 0.20 mm., lov 0.25 mm.

The zoarium of *C. oranense* has an encrusting base, from which grow erect,

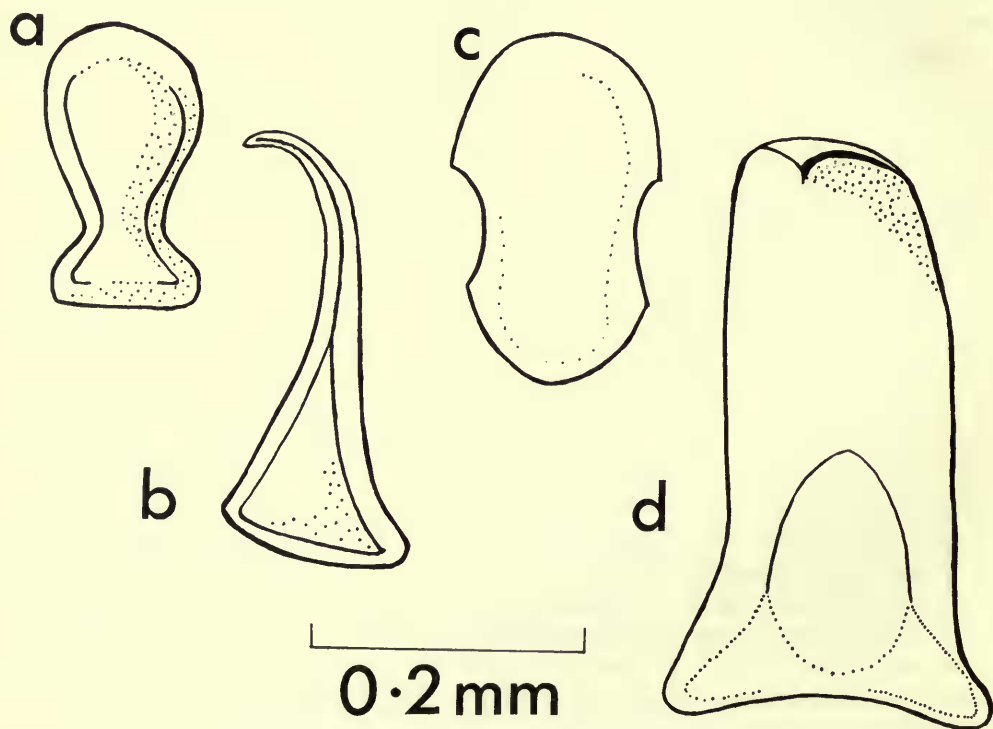


FIG. 6. Opercula and mandibles in *Cleidochasma*. A, B. *C. oranense*. A. Operculum. B. Mandible, Ghana, Achimota Coll., 32D. C, D. *C. brancoense*. C. Operculum, Bay of Biafra, "Calypso" Coll., C55F. D. Mandible, Cape Verde Islands, "Calypso" Coll., C97A².

irregular branches which occasionally anastomose. The colony is frequently large (maximum height observed 60 mm.), and the branches are hollow, or in some cases grow round an algal or hydroid core. The structure of each branch is plurilaminar, secondary layers being budded from the base of the branches ; these usually grow in the same direction as the primary layer (cf. *C. brancoense* below).

The operculum has been figured by Waters and Barroso ; it is semi-globose distally, and usually golden-brown in colour. Barroso also figured the pair of large distal rosette plates. In *C. oranense* the distal wall of each zooecium is concave, and thus the rosette plates are closer together than those of *C. brancoense* (see below).

The avicularian chambers communicate with the neighbouring zooecia by lateral septula, but do not reach the basal wall of the zoarium. Each zooecium usually has an avicularium on one distal-lateral wall, but occasionally it may be absent ; the avicularia seem to arise above the marginal pores, after the zooecial walls have been laid down at the growing edge.

Ovicells do not appear to have been described before in *C. oranense*. When young, they are large, wide and prominent, with a small area on the proximal border. They are rapidly immersed by secondary calcification, and even in slightly older parts of the colony they are inconspicuous, the obscured distal part of the operculum being the only sign of the presence of a fertile orifice, which does not otherwise differ in any way from those of other zooecia (see pl. 2 fig. 3).

C. oranense is known only from the north and west African region, from Oran to the coast of Ghana. It has not been reported from Madeira or the Cape Verde Islands, and is absent from the Bay of Biafra (cf. *C. brancoense* below).

14. *Cleidochasma brancoense* (Calvet)

(Pl. 2, fig. 4, Pl. 3, fig. 1, Text-fig. 6C-D)

Lepralia brancoensis Calvet, 1906a : 159 ; 1907 : 410, pl. 27, figs. 6-9, Cape Verde Islands, Ilot Branco, 110-180 m. Waters, 1918a : 4 (listed only).

MATERIAL (specimens with ovicells* marked with an asterisk). "*Calypso*" Coll. I. Stn. 45, 0° 25' N, 9° 1' E, 8.vi.56, 73 m., C55F* (with *C. porcellanum* C55C).

Coll. II. Stn. 24, 15° 16' 34" N, 23° 47' 44" W, 18.xi.59, 55-60 m., C91I, C94A, C97A*. Stn. 26, 15° 16' 30" N, 23° 47' 31" W, 18.xi.59, 50-65 m., (île Sao Tiago), C65L*, C127F*. Stn. 31, no details, C66R.

C. brancoense is not present in the Marche-Marched or Achimota Collections.

DIAGNOSIS. Zoarium encrusting with erect, plurilaminar, irregular anastomosing solid branches formed by spiral growth. Zooecia with large marginal and occasional frontal pores. Orifice with 2 oral spines, cleithridiate, with a pair of large condyles forming a subtriangular sinus. Operculum with a pair of lateral sclerites. 2 distal and 1-2 lateral rosette plates. A pair of small rounded avicularia with a complete bar and rounded or triangular mandibles, level with the distal border of the orifice, usually directed inwards and slightly proximally, frequently present, also on the fertile zooecia. Occasional large interzooecial avicularia, with a complete bar and elongated spathulate mandibles present. Ovicells hyperstomial but immersed,

becoming obscured by secondary calcification, with a small area on the proximal frontal border.

Dimensions. Lz 0.60 mm., lz 0.45 mm., Lo 0.26 mm., lo 0.16 mm., Lop 0.25 mm., lop 0.15 mm., La 0.15 mm., La (interzoecial) 0.50 mm., Lm (interzoecial) 0.40 mm., Lov. 0.25 mm., lov. 0.37 mm.

The zoarium of *C. brancoense* is very similar in appearance to that of *C. oranense*, but differs in the method of growth of the erect branches, which are solid. The secondary layers may arise randomly on the primary layer and develop in any direction from these foci, some branches when broken show a spiral structure similar to that of *Hippoporida senegambiensis* (Carter) (see p. 25).

The distal wall of each zoecium is convex, with a strong central ridge; thus the pair of rosette plates are widely separated, unlike those of *C. oranense*.

The large interzoecial avicularia are sporadic in occurrence, often being absent over areas of the colony.

Calvet's material had no ovicells; those in the "Calypso" specimens are larger and wider than those of *C. oranense*, and are even more rapidly obscured by secondary calcification; only a few show a small area on the proximal border.

C. oranense and *C. brancoense* are closely related species; the distribution of *C. brancoense* is confined to two widely separated areas, the Cape Verde Islands and the Bay of Biafra, in neither of which *C. oranense* has been found.

15. *Cleidochasma rotundorum* (Norman)

(Pl. I, fig. 2, Text-fig. 5B, C)

Cellepora janthina (Smitt) Waters, 1899: 14, pl. 3, figs. 1-3, Madeira (not *Hippoporida janthina*, see p. 27). Canu & Bassler, 1920: 615, text-figs. 185A-E.

Cellepora rotundora Norman, 1909: 311, pl. 42, figs. 8, 9, Madeira, 70 fath.

Hippotrema rotundora (Norman) Canu & Bassler, 1928a: 141.

LECTOTYPE, chosen here, specimen in the Museo do Seminario, Funchal, figured here on pl. I, fig. 2.

LECTOPARATYPES, remaining specimens on the same slide.

MATERIAL.

British Museum, Madeira, 70 fath., 1911.10.1.1664, Norman Coll.

C. rotundorum is not present in the "Calypso" Collections, the Marche-Marchad Collections or the Achimota Collections.

DIAGNOSIS. Zoarium encrusting, plurilaminar or discoidal. Zooecia with marginal pores and 2-3 rows of frontal pores, the area proximal to the orifice non-porous. 1-2 lateral and 2 distal multiporous rosette plates present. Orifice rounded, with a pair of distinct denticles forming a shallow, rounded sinus; peristome raised laterally and a small proximal umbo sometimes present. Avicularia adventitious, frequently paired, beside the sinus, directed distally, with a complete bar and triangular mandible. Ovicells prominent, globose, finely and regularly tuberculate, with a very large triangular membranous frontal area.

Dimensions. Lz 0.45 mm., lz 0.30 mm., Lo 0.13 mm., lo 0.13 mm., Lav 0.09 mm., Lov 0.20 mm., lov 0.27 mm.

C. rotundorum somewhat resembles *C. mirabile* Harmer (1957 : 1045, pl. 71, figs. 15, 17, 18, text-fig. 113 ; 600D, Borneo Bank, 59 m.), which also has globose, tuberculate ovicells with large frontal areas, and similar avicularia. *C. rotundorum* differs in the less elongated shape of its orifice and in the absence of oral spines. The zoarium of *C. mirabile* is selenariiform, and the basal surface has characteristic deep depressions (see Harmer, 1957 : 1045). *C. rotundorum* may perhaps assume a selenariiform habit, but the lectotype and the specimens in the Norman Collection are all encrusting. Some colonies in both collections grow over small lamellibranch shells, almost covering both surfaces and thus producing conical, free colonies. These may be those described as "disk-shaped" by Waters. The remainder of the specimens encrust calcareous tubes of the serpulid worm, *Ditrupa arietina*¹ (O. F. Müller).

Waters's figure of the ovicells of *C. rotundorum* shows the extensive frontal areas more clearly than that of Norman, where they are drawn in foreshortened view. Only one ovicell in Norman's Madeiran specimens has the membranous covering in position, in all the others it is no longer present, and in many the ovicell is broken, only the basal wall remaining (see Text-fig. 5C).

The frontal pores are more extensive in this species than in any other *Cleidochasma*, but are not found in the central sub-oral area, which is tuberculate and often umbonate. Waters mentioned the umbo, but both he and Norman illustrated the frontal as uniformly porous. Canu & Bassler (1927 : 21, 31 and 1928a : 141) erected the genus *Hippotrema* for forms with tremopores, including *L. rotundora*, and, as type-species, chose *Lepralia edax* forma *janthina* Smitt (see p. 27), which was also originally figured with a porous frontal. Unfortunately Canu & Bassler did not figure specimens of *Hippotrema janthina*, but referred only to their earlier text-figures of the "*Cellepora janthina* group of Waters" (1920 : 615, text-figs. 185 A-E). These figures are copies of Water's (185A-C) and Norman's (185D-E) illustrations of *C. rotundorum*, not of *H. janthina* (Smitt). Osburn (1952 : 354) pointed out that the frontal of *H. janthina* was not a tremocyst, but that the rows of sub-marginal pores were "carried up" in the calcification to produce an appearance of tremopores. Examples of this type of calcification may also be seen in *Cleidochasma spiculiferum* (Canu & Bassler), which was also originally referred to *Hippotrema* (see below), and in the "cortical zooecia" of *Hippoporida* (see p. 22).

16. *Cleidochasma granulosum* (Canu & Bassler) and *C. spiculiferum* (Canu & Bassler)

Hippoporida and *Cleidochasma* have many characters in common. *Hippoporida* is here restricted to species with "cortical zooecia" and a special type of interzooecial avicularium, which encrust gastropod shells (see also Lagaaij, 1952 : 147).

Osburn (1952 : 356-7) included *Hippoporida granulosa* Canu & Bassler (1930a : 43, pl. 8, figs. 1, 2 ; Galapagos, 40 fath.) and *Hippotrema* (?) *spiculifera* Canu & Bassler (1930a : 43, pl. 8, figs. 3-5, Galapagos, 40 fath.) in *Hippoporida*. Both species have 6 oral spines, a character absent in *Hippoporida*, and, although

¹ Notes on the identification of this worm and of another associated Polyzoan, *Bugula ditrupae* Busk, from Madeira, are given by Ryland (1960 : 94-96).

H. granulosa encrusts shell, neither have any association with Gastropod or hermit-crab, nor do they possess cortical zooecia or interzooecial avicularia. Thus neither can be referred to *Hippoporidra* as defined here. Specimens of *H. granulosa* (Galapagos, 40 fath., 1933.12.10.29, "part of type material", and 1933.12.10.10, Canu & Bassler Coll.) have a pair of small distal rosette plates, an elongate, cleithridiate orifice, with an operculum (like that figured by Osburn, 1952, pl. 42, fig. 14) which greatly resembles that of *Cleidochasma porcellanum*. A specimen of *Hippotrema* (?) *spiculifera* (Galapagos, 40 fath., 1933.12.10.6, Canu & Bassler Coll.) has a pair of distal rosette plates and an orifice very like that of *C. rotundorum*. The numerous ovicells (which were not found by Canu & Bassler) also resemble those of *C. rotundorum* and *C. mirabile*, being large, globose, finely tuberculate, and having a large triangular membranous frontal area. The avicularia are adventitious, and the long curved mandible is directed proximally. Both *H. granulosa* and *H. spiculifera* are here referred to *Cleidochasma*.

17. *HIPPOPORIDRA* Canu & Bassler

Hippoporidra Canu & Bassler, 1927 : 21, 31 ; 1929 : 418, text-fig. 163. Lagaaij, 1952 : 147.

TYPE SPECIES, *Cellepora edax* Busk, 1859 : 59, pl. 9, fig. 6 ; pl. 22, fig. 3, Pliocene, Suffolk.

DIAGNOSIS. Zoarium normally encrusting Gastropod shells, frequently (perhaps exclusively) those inhabited by hermit-crabs ; plurilaminar, nodular, branched, massive. Autozooecia with marginal pores and a few frontal pores, and with dietellae. Orifice hippoporine, variable, with a pair of strong denticles. Oral spines absent. Nodules and branches formed by *cortical zooecia*, with 3-4 rows of frontal pores and reduced orifices. Avicularia small, frontal, and small and large *interzooecial*, with triangular and spatulate mandibles. Ovicells hyperstomial, with a frontal area, not closed by the operculum.

Cortical zooecia. Large zooecia (Lz twice that of autozooecia), recumbent in the primary layer, erect in subsequent layers. Frontal apparently pierced by tremopores but in fact, with 2-3 rows of "carried up" pores (see above). Orifices reduced, surrounded by large peristomial tubercles. Polypides not found, zooecial cavity lined by a thick yellow membrane and filled with fibrous and granular material. These cortical zooecia form the base and core of the nodules and branches.

Interzooecial avicularia. Avicularia in which the sub-rostral chamber is very large, with dietellae, and a frontal wall with both marginal and frontal pores. In the primary layer a small avicularium is centrally placed and variously orientated. In the later, superposed layers, where these avicularia form part of nodules or branches, the erect nature of the sub-rostral chamber reduces the extent of the frontal, and the avicularium may appear to be adventitious. The largest avicularia are only found as part of the nodules or branches. The sub-rostral chamber is large and very convex, and the mandibles are very variable in shape. The muscles fill the sub-rostral chamber.

Each species of *Hippoporidra* displays a wide individual range of variability, but some characters seem to be fairly constantly correlated, and it is upon these that

specific status is based in the descriptions below. It must however be stressed, that until the breeding and development of living colonies have been observed, together with a full analysis of the association with Gastropod and/or hermit-crab, the separation of the records and specimens below into species, is of necessity arbitrary, and may not reflect actual relationships.

18. NOTES ON THE ASSOCIATION OF GASTROPODS AND PAGURIDS (HERMIT-CRABS) WITH ENCRUSTING ANIMALS

A number of animal species are known to live upon the shells of Gastropods, whether these are inhabited by the Mollusc or by hermit-crabs. Stechow (1921 : 29-31) described two encrusting coelenterates, *Janaria mirabilis* and *Hydrocorella africana*, with branched growths. Specimens of *H. africana* examined (Coelenterate section register, 1957.4.26.22, False Bay, S. Africa), measure 13 mm. across, but have no branches, and are botryoidal. A very fine lamina of the Coelenterate grows out around the orifice of the shell, as in *Hippoporida* (see p. 25). Growth of a similar lamina was also noted by von Marten (1877 : 183) in an un-named Polyzoan associated with a hermit-crab from South Africa (see p. 32). Hesse & Doflein (1943 : 533, text-fig. 596), described a spiny Coelenterate, *Hydractina sodalis*, encrusting a shell inhabited by *Eupagurus* sp. *H. sodalis* is similar to *Palythoa senegambiensis* Carter (1882 : 418, pl. 16, fig. 2A-C, 3A, B) which has 4 erect arms. Other associations of Coelenterates with hermit-crabs were noted by von Marten (1876 : 20).

Botryoidal colonies of the Ctenostomatous Polyzoan *Alcyonidium nodosum* were described by O'Donoghue & de Watteville (1944 : 428, pl. 16, figs. 17, 18) and O'Donoghue (1957 : 92), encrusting a Gastropod, *Comminella papyracea* from S. Africa. Specimens of *A. nodosum* (1963.3.20.12, Port Nolloth and Lamberts Bay, S. Africa, O'Donoghue Coll.) show that the large zooecia forming the nodules somewhat resemble the cortical zooecia of *Hippoporida* (see p. 22). They are about twice the length of the autozooecia, and appear to be filled with granular material. Plurilaminar, erect irregular branches are present in *A. polyphyllum* Marcus (1941 : 63, pl. 8, fig. 27) encrusting *Murex* from Brazil, but the description does not mention groups of enlarged zooecia.

The membraniporan Cheilostome, *Antropora tinctoria* (Hastings) produces plurilaminar erect branches (up to 50 mm. in length) when encrusting gastropod shells inhabited by hermit-crabs (see Osburn, 1950 : 54, pl. 4, fig. 7 ; pl. 29, figs. 7-8, S. California to Galapagos). The original colonies described by Hastings (1930 : 708) encrust shell fragments and stones, and although plurilaminar, have no erect outgrowths. In *Conopeum commensale* Kirkpatrick and Metzelaar (1922 : 983, pl. 1, fig. 1-9, pl. 2, fig. 14) from west Africa, which is associated with hermit-crabs, the zoarium is plurilaminar without either nodules or erect branches (Cook MS).

Several Polyzoan species, all with branched zoaria and all associated with hermit-crabs, have been recorded from west Africa. Unfortunately their zooecial characters were not described, and although it is very probable that they are synonymous with *Hippoporida senegambiensis*, *H. picardi* or *H. littoralis* this cannot be established beyond doubt. The records are as follows :—

(a) *Keruniella valdiviae* and *Cellomma keruniformis*, from the mouth of the Congo, associated with *Eupagurus pollicaris* Say var. *alcocki* Balss. ; see Stechow, 1921 : 31 and Doflein, 1914 : 350, text-fig. 302C. Fig. 302D shows *Eupagurus varians* Bened. with a similar branched growth covering the shell inhabited by the hermit-crab.

(b) *Eschara perosa* Kirchenpauer MS, Studer (1889 : 28), on a Mollusc shell. The colony had cylindrical branches and was from a sandy substrate off west Africa (4° 40' N, 9° 10' W, with *Cupuladria* sp.). Studer (p. 54) also listed *Eschara* sp. from S. Africa (33° 59' S, 17° 52' E, 91.5 m.) growing on *Fusus mandarinus* inhabited by *Eupagurus unguatus* Studer. This specimen was figured (pl. 23, fig. 8A) with two stout branches, at 180° to one another, extending laterally from the orifice of the shell. It is very similar in appearance to the figure of "*Schizopodrella*" sp., associated with *Pagurus corallinus* given by Schmitt (1931, text-fig. 43), which had in addition a median branch (see p. 25).

Roger & Buge (1948 : 461-470) examined several species of fossil and Recent Polyzoa encrusting shells, by means of X-ray photography. They concluded that in the fossil specimens the association was between Polyzoan and Gastropod, not Polyzoan and hermit-crab. However, Buge (1957 : 320-323), having examined a large number of Recent specimens from west Africa using the same methods, concluded that it was possible that the association was between Polyzoan and Pagurid. He also considered whether the association might be primarily with the Gastropod, and secondarily with the Pagurid, but inclined to the former theory. The lectotype and other specimens of *H. edax* have been examined by means of X-rays. No positive evidence of association with hermit-crabs has been found in the fossil specimens, but of 200 Recent specimens of *H. edax* and *H. senegambiensis* examined 120 were inhabited by hermit-crabs. In young colonies the proportion is even higher ; 41 out of 50 specimens of *H. senegambiensis* (Achimota Coll. 87AI) had hermit-crabs present. In no case has a Mollusc been found, all the remaining shells being apparently empty. A few shells from west Africa examined from the Mollusca Section of the British Museum had no Polyzoan encrustation and were inhabited by the original Gastropod. Thus it appears that the association in Recent species is undoubtedly between Polyzoan and Pagurid.

In the lists of material below, those shells which can be seen to be inhabited by a hermit-crab are marked with an asterisk, thus :—IIA*.

19. DEVELOPMENT AND STRUCTURE OF THE ZOARIUM IN *HIPPOPORIDRA*

Some of the larger shells indicate that there may be initial settlement of several larvae and that the final zoarium is formed by the most successful colony ; but, in the great majority of shells, the zoarium appears to be the result of the settlement of a single larva. The following specimens, all of *H. senegambiensis*, are particularly instructive :— Marche-Marched Coll. I, 6D, III, 9A ; Achimota Coll. I, 44I, 87AI, II, 9A. In one case (44I) the ancestrula is visible ; the orifice is rounded, with very little sinus. In all these specimens the colony starts from a point near the orifice of the shell, and, where a hermit-crab is present, above the flexure of the larger chela.

The colony first develops as a unilaminar sheet over the shell, producing cortical zooecia and interzooecial avicularia. Nodules of plurilaminar growth, with cortical zooecia at their centre, and groups of ovicells in the hollows between them, are evident, often before the shell is completely covered by the primary layer of zooecia. Where the shell is of the long-spined *Turritella* type, the first branch is developed early, also before the shell is completely covered ; it is almost invariably at an angle approaching 180° to the long axis of the shell, so that it grows in the direction away from the spire. Subsequent branches tend to develop in a median position in a plane at 90° to the spire of the shell. On short-spined shells or those where several barnacles have also settled, the growth is nearly always nodular and branches are rarely formed, and there seems to be some correlation between shell-type and zoarial form. The erect branches are themselves nodular, with groups of cortical zooecia, and secondary branching occurs in large zoaria. The cortical zooecia apparently form the core of each branch, each group budding further individuals, while the surrounding autozooecia grow up and cover the protuberance thus formed. Sections of branches show the large central cortical zooecia, and the small zooecia of the covering layers, which appear to develop spirally in some zoaria (cf. *Cleidochasma brancoense*, p. 20). Some very large colonies are almost globular, and appear to be the result of plurilaminar growth between the branches, which becomes so thick that they are obscured.

The zoarium is usually extended as a lamina surrounding the shell-orifice and forming a cowl over the carapace of the hermit-crab. This is particularly well-developed in some specimens of *H. picardi* (Marche-Marchad Coll. III, 11A) where the lamina has also developed ventrally to the Pagurid and formed a tube. In one of these zoaria the tube has become so extended that its orifice is apparently too small for the Pagurid to pass through. The pattern of zooecia which is seen on the basal side of the free lamina has led some authors to presume that it marks the position of the original shell orifice and that the shell itself has been eroded by the Polyzoan (see Busk, 1859 : 59, and Carter, 1882 : 417). Both X-ray photographs and broken specimens show that the shell is not eroded and is present even in large colonies, where there is considerable plurilaminar growth. For example, *H. senegambiensis* from Loanda, 1896.7.30.1, is a broken zoarium in which the shell may be seen embedded in from 30–50 layers of zooecia.

The pigmentation of the zoaria of *H. janthina* was noted by Smitt (1873 : 64) and Osburn (1952 : 355). Carter (1882 : 417) described the pigmented areas of *H. senegambiensis* in detail, but examination of the plentiful material now available has shown that their distribution is not constant. Carter found that the cortical zooecia were pigmented and the surrounding depressed fertile areas were not. Zoaria with this type of pigmentation, and also with the reverse arrangement are present in *H. senegambiensis* from the Marche-Marchad Coll. III, 14A. A section through a branch shows that the areas of pigment alternate in position throughout the growth of the colony.

The very large interzooecial avicularia are usually present at the base of the nodules and branches, surrounding the groups of ovicells, which are always found

in the hollows between the cortical zooecia, as noted by Carter (1882 : 417). The frontal area is completely membranous in young ovicells of all species, but it rapidly becomes calcified, resulting in a semicircular plate with a small distal, membranous pore.

20. *Hippoporidra edax* (Busk)

(Pl. 3, figs. 5-7)

Cellepora edax Busk, 1859 : 59, pl. 9, fig. 6, pl. 22, fig. 3, Pliocene (Gedgravian), Suffolk ; 1861 : 154, pl. 34, figs. 3, 3A, Coast of Devon. Duvergier, 1924 : 46, pl. 6, figs. 5-10, Helvetian, Miocene, France.

Lepralia edax (Busk) Moore, 1937 : 202, on shell containing *Eupagurus cuanensis*, Fleshwick Bay and N. of Kitterland, 18 fath., S.W. coast of the Isle of Man.

Hippoporidra edax (Busk) Lagaaij, 1952 : 147, pl. 15, fig. 13, pl. 16, fig. 6, Pliocene, Netherlands, synonymy. Buge, 1957 : 320, pl. 11, fig. 2, pl. 12, figs. 3-6, Redonian, western France.

LECTOTYPE. B. 1620, B.M. Palaeontology Department.

MATERIAL. *British Museum*, Palaeontology Dept. B. 1620 and D. 60463, Coralline Crag, Pliocene, Britain.

Zoological Dept., Coast of Devon, 1899.7.1.1410, Busk Coll., fig'd Busk, 1861. Guernsey, 1899.7.1.1410A, 1963.4.16.1, Busk Coll. 1887.7.29.49 (chitinous parts). 1911.10.1.1143, Norman Coll. Plymouth, 1899.5.1.1517, Hincks Coll. Scilly, 35 fath., 1963.3.30.273, Harmer Coll. Port Erin, Isle of Man, 1963.12.30.1*, Eggleston Coll.

Sedgwick Museum, Cambridge. C51007-8, Coralline Crag, Orford Castle, Suffolk. C51009-14, Orford. C51015-26, Hall pit, Sudbourne, Suffolk. C35829-33, Gedgrave, Suffolk. C51395, Sudbourne, Suffolk.

H. edax is not present in collections from west Africa.

Diagnosis. Zoarium encrusting Gastropod shells plurilaminar, nodular. Zooecia with marginal and a few frontal pores. Orifice with a fairly wide, rounded sinus. Cortical zooecia with more numerous frontal pores and reduced orifice. Small acuminate and large acute interzooecial avicularia present, with doubly constricted bar. Ovicell with frontal area.

Dimensions. Lz 0.33 mm., Lz (cortical) 0.60 mm., lz 0.30 mm., Lo 0.10 mm., lo 0.08 mm., Lo (cortical) 0.02 mm., lo (cortical) 0.02 mm., Lav 0.10 mm., Lov 0.13 mm., lov 0.14 mm.

Lagaaij gave his reasons (1952 : 140, 148) for regarding *Cellepora parasitica* Michelin, 1847 as a synonym of *H. edax*, rather than of *C. parasitica* Busk, 1859. The dome-shaped zoarium described as *Lepralia edax* by Waters (1885 : 297) from the River Murray Cliffs, Australia, may have belonged to *Conescharrellina*. Duvergier (1924 : 46) first noted that the zooecia composing the zoaria of *C. edax* were of two kinds, and he described the irregularly porous frontal of the cortical zooecia. The Recent specimens from S.W. Britain and the Channel Islands have been included here with the Pliocene material which they resemble more than the closely related *H. janthina* and *H. senegambiensis*. The orifices of *H. edax* have a smaller, deeper sinus than those of *H. janthina*, and the interzooecial avicularia are all acuminate, not spatulate, as in *H. senegambiensis*. The zoaria of *H. edax* are also apparently

always nodular, without erect branches, although this may be more a function of the type of shell available than a specific character (cf. *H. littoralis* p. 28).

The zoarium of the lectotype is nodular, measuring 15 mm. \times 20 mm. The majority of the zooecia are small with few or no frontal pores. The cortical zooecia are considerably larger with small pits indicating frontal pores. Few avicularia are present, but the same types are present in larger numbers in the specimens from Guernsey and Devon. Ovicells are present in the lectotype (cf. Lagaaij, 1952 : 148) ; they are almost hidden on the face of the shell nearly concealed by the slide, but may be seen by tilting the mount. These ovicells are incomplete, the frontal wall no longer being present, but they so greatly resemble broken ovicells of Recent specimens that it is reasonable to assume that they, too, possessed a similar delicate frontal area.

The specimens in the Sedgwick Museum also have broken ovicells, and zoaria from the series C35829-33 show the frontal pores of the cortical zooecia particularly clearly.

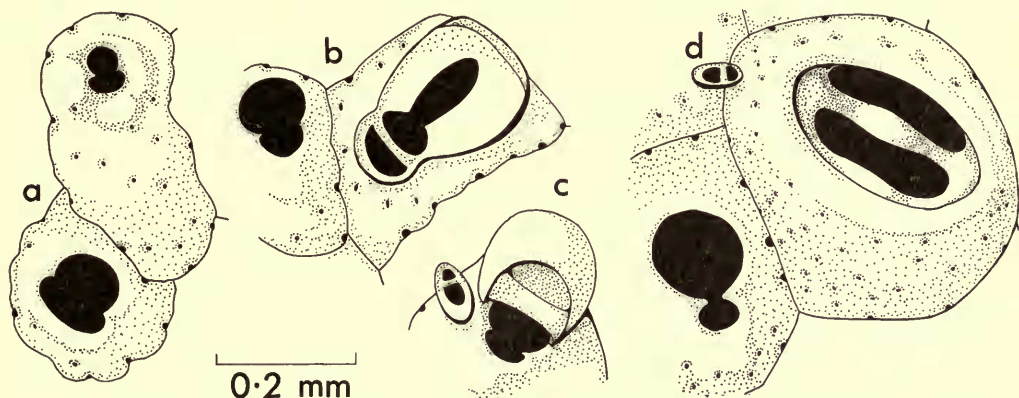


FIG. 7. *Hippoporidra*, treated with eau de javelle. A. *H. littoralis*, zooecium and cortical zooecium, Ghana, Achimota Coll., 7B. B, C. *H. senegambiensis*. B. Zooecium and inter-zooecial avicularium. C. Ovicell, Ghana, Achimota Coll., 14I. D. *H. picardi*, zooecium and inter-zooecial avicularium, Senegal, Marche-Marchad Coll. I, 33H.

21. *Hippoporidra janthina* (Smitt)

Lepralia edax forma *janthina* Smitt, 1873 : 64, pl. 11, figs. 224, 225, off Florida.

Lepralia maculata Ulrich & Bassler, 1904 : 423, pl. 115, figs. 8a, b, and 9, pl. 118, fig. 7, Calvert Formation, Plum Point, 3 miles S. of Chesapeake Beach, Miocene.

Cellepora minuta Canu & Bassler, 1923 : 182, pl. 25, figs. 10-13, Miocene, N. Carolina, and Pliocene, S. Carolina.

Hippotrema janthina Canu & Bassler, 1928a : 141 (not *Cellepora janthina* Waters = *Cleidochasma rotundorum* see p. 20).

Hippoporidra janthina (Smitt) Osburn, 1952 : 355, pl. 45, figs. 13-15, Gulf of California to Lower California, 2-60 fath.

Hippoporidra edax (Busk) : Soule & Duff, 1957 : 113, Pleistocene, California.

MATERIAL. *British Museum*, Gulf of Mexico, 28° 58' N., 89° 9' W., 1961.II.2.14, Cheetham Coll.

H. janthina is not present in the collections from west Africa.

DIAGNOSIS. Zoarium encrusting Gastropod shells, nodular or branched. Zooecia slightly larger than those of *H. edax*, with marginal pores and 2 rows of frontal pores. Orifice with very shallow wide sinus. Small avicularia frequent, larger acuminate avicularia rare. Ovicell wide, with rounded frontal area.

Dimensions. Lz 0.45 mm., lz 0.35 mm., Lo 0.13 mm., lo 0.13 mm.

H. janthina is obviously very closely related to *H. edax*, being distinguished by the wider shallower sinus and the greater frequency of frontal pores. At present, all western Atlantic records are grouped here under *H. janthina*. Soule & Duff stated that *H. edax* had not been "reported as living from the Pacific coast"; there is evidence (Cook MS), that a living form closely related to *H. janthina* has been recorded from Mazatlan, Mexico.

22. *Hippoporidra littoralis* sp. n.

(Pl. 1, fig. 3, Text-fig. 7A)

HOLOTYPE. B.M. 1963.4.16.3, Achimota Coll. Stn. C.

MATERIAL. *Achimota Coll. I.* Stn. C, Winneba shore, rock face, 22.xi.49, 7B,* Paratypes. Stn. U, Tenpobo, No. 1 reef, 21.xi.49, 67F, and *Coll. II*, 4A, 17.i.49. Stn. X, Axim, Hospital reef, 7.i.51, 68E.

British Museum, Malacostraca Section, Apam, Ghana, with *Pseudopagurus granulimanus* (Miers) *biafrensis* (Monod), 1958.5.9.116-7.*

H. littoralis is not present in the "Calypso" or Marche-Marchad Collections.

DIAGNOSIS. Zoarium plurilaminar, nodular. Zooecia with marginal and at most a few scattered frontal pores, frequently with none. Orifice with anter narrower than poster, with a pair of denticles and sub-oral umbo large, constant. Cortical zooecia larger than autozooecia, orifice much smaller, surrounded by large blunt tubercles. Small rounded and semi-circular interzooecial avicularia present, none very large, often extremely rare. Ovicells with frontal area. Inhabits littoral and shallow waters.

Dimensions. Lz 0.28 mm., lz 0.30 mm., Lz (cortical) 0.45 mm., lz (cortical) 0.40 mm., Lo 0.13 mm., lo 0.13 mm., Lo (cortical) 0.07 mm., lo (cortical) 0.05 mm., Lov 0.15 mm., lov 0.18 mm.

It is possible that *H. littoralis* may be found to be a form of *H. senegambiensis* related to growth on short-spined shells (with hermit-crabs), of shallow waters. Until it can be discovered whether the ecological conditions inherent in the Pagurid association are able to affect zooecial as well as zoarial characters, the features in which these specimens differ from *H. senegambiensis* and *H. picardi* must rank as specific. The orifice is constantly wider proximally than distally, even in the cortical zooecia. This is a condition approached by some zooecia of the primary layer in *H. senegambiensis*, but not to the same degree, or so constantly. This type of orifice is also similar to that of *H. janthina*, from which *H. littoralis* differs in the form of the zoarium, the scarcity of frontal pores, and in the type of avicularia present.

H. littoralis is confined to the shore of Ghana. Forest (1956 : 338, text-fig. 2)

gave the distribution of the hermit-crab, *Pseudopagurus granulimanus biafrensis* as intertidal, and the association of *H. littoralis* may always be with this and similar littoral species. It may be compared with the deeper water association between *Diogenes ovatus*, *Turritella* shells and *H. senegambiensis*.

23. *Hippoporida senegambiensis* (Carter)

(Pl. 3, figs. 3-4, Text-figs. 7B-C, 8A-D)

Cellepora senegambiensis Carter, 1882 : 416, pl. 16, figs. 1A-V.

LECTOTYPE. Chosen here B.M. 1963.4.16.2A, Guinea, West Africa.¹

LECTOPARATYPES. 1963.4.16.2B, C.

MATERIAL. "*Calypso*" Coll. I. Stn. 6, 10° 19' N., 16° 33' 40" W., 16.v.56, 73-60 m., C2, specimen 4. Stn. 7, 9° 40' N, 13° 35' 5" W, 12.v.56, 8m., C4C*. Stn. 17, 5° N., 5° 28' 30" W., 21.v.56, 27 m., C56H and C36A*, with *Diogenes ovatus* Miors. Stn. 19, 5° 2' 30" N., 5° 24' 40" W., 21.v.56, 21-27 m., C41A. Stn. 45, 0° 25' N., 9° E., 8.vi.56, 73 m., C55E.

Marche-Marchad Coll. I. Konakrey, Guinée Ise, II. Baie de Gorée, 1954, 46-48 m., 6D. Sud de Gorée, 24.xi.53, 40-41 m., 11M. A l'est de Gorée, 6.iv.54, 47I*.

Coll. III. "*Gerard Freca*", Dragage 1, 18.ii.54, 23J ; 5, 15F ; 7, 8A. Sud de Gorée, 13.xi.53, 33-35 m., 9A* ; 34-37 m., 17A*. Devant l'Anse de Bernard, Dakar, 12 m., 10A*. Baie de Gorée, 14A. Either S.W. Madeleines, 15.ix.53, 48 m., or Sud de Gorée, 13.xi.53, 34-37 m., 17A*. Devant le "Castel", Gorée, 15 m., 22A* ; 33-34 m., 27.xi.53, 29B ; 24K*, no information.

Achimota Coll. I. Stn. K, on trawl debris 1 mile offshore, 2 miles W. of Densu R., 2.iii.49, 4 fath., 44I. Stn. 47, dredge haul No. 1, 4.i.51, 44 m., 14I. Stn. 62, dredge haul No. 2, 18.i.51, 30 m., 87IA*. Stn. 63, as above, 36 m., 87IIA. Stn. 71, as above, 24.i.51, 30 m., 73A*. Stn. 98, as above, 14.iii.51, 25 m., 3B*. Stn. 112, Agassiz trawl No. 3, 4.iv.51, 43 m., 60S and Coll. II, 10A*. Stn. 130, Agassiz trawl, No. 2, 26.iv.51, 32 m., 70B* and Coll. II, 9A*. Stn. 131, as above, No. 1, 2.v.51, 37 m., 43U. Stn. 132, as above No., 44 m., 50F.

Coll. II. Stn. 133, as above, No. 3, 51 m., 7G. Stn. 117, as above, No. 2, 5.iv.51, 64 m., 13F. Stn. 126, as above, No. 3, 12.iv.51, 16 m., 11A (W).

Forest Coll. No. 3*, M'Bizi, Stn. 26, 1948-49, avec *Eupagurus alcocki* Balss (W). No. 4, Dakar, iv.1951. No. 5*, devant Joal, Senegal, 25 m., with *Diogenes ovatus* Miors. No. 6*, Baie de Rufisque, Gorée, 18.i.52, 10-15 m., with *D. ovatus* and *Paguriste fagei* Fort. No. 7*, Entre Rufisque et Gorée, 26.iii.53, 25 m., with *D. ovatus*.

British Museum, Guinea, west Africa, 1963.4.16.2. Guinea coast, 1904.7.16.1, 2, 3, 4 (W). Cape Blanco, 1922.9.12.1*. Loanda, Angola, S. of da Costa, 1896.7.30.1 (W). Locality ? 1851.11.14.82, Belcher Coll.

¹ Carter (p. 419) gave the location of his specimens as "Liverpool Free Public Museum". Mrs. N. McMillan, of the City of Liverpool Museums, informs me (*in litt.* 29.7.1963) that "they must be presumed lost in the bombing". The specimens in box 1963.4.16.2 were labelled as "Type specimens of *Cellepora senegambiensis* Carter" by Kirkpatrick, but none of them is that figured on pl. 16, fig. 1, by Carter.

DIAGNOSIS. Zoarium usually with long branched rugose arms. Zooecia small, with marginal pores and a few scattered frontal pores. Orifices of primary layer with a wide shallow sinus, orifices of subsequent layers usually with a rounder, deeper sinus. Cortical zooecia large, with 3-4 rows frontal pores, and very small orifices with large peristomial tubercles. Small adventitious avicularia frequent, large and small interzooecial avicularia with triangular and spatulate mandibles. Ovicells with frontal area, occasionally tuberculate.

Dimensions. Lz 0.30 mm., lz 0.25 mm., Lz (cortical) 0.70 mm., lz (cortical) 0.50 mm., Lo 0.10 mm., lz 0.10 mm., Lo (cortical) 0.08 mm., lo (cortical) 0.05 mm., Lm 0.04-0.15 mm., Lov 0.11 mm., lov 0.15 mm.

The orifices of the zooecia of the primary layer differ from those later zooecia in that their sinuses are wide and shallow, like those of *H. janthina*. They are never as wide as those of *H. littoralis*, but in a few colonies the primary type persists in a large number of the zooecia which form the plurilaminar branches. These zoaria are also marked by the predominance of the triangular type of inter zooecial avicularium and are labelled "W" in the lists of material above. Colonies of *Hippoporida* sp. from Fiji (1862.2.4.13) and the Philippines (1882.7.29.48 and 1899.7.1.3518, 3519) also have orifices with a wide sinus and avicularia with triangular mandibles, which are, however, much shorter.

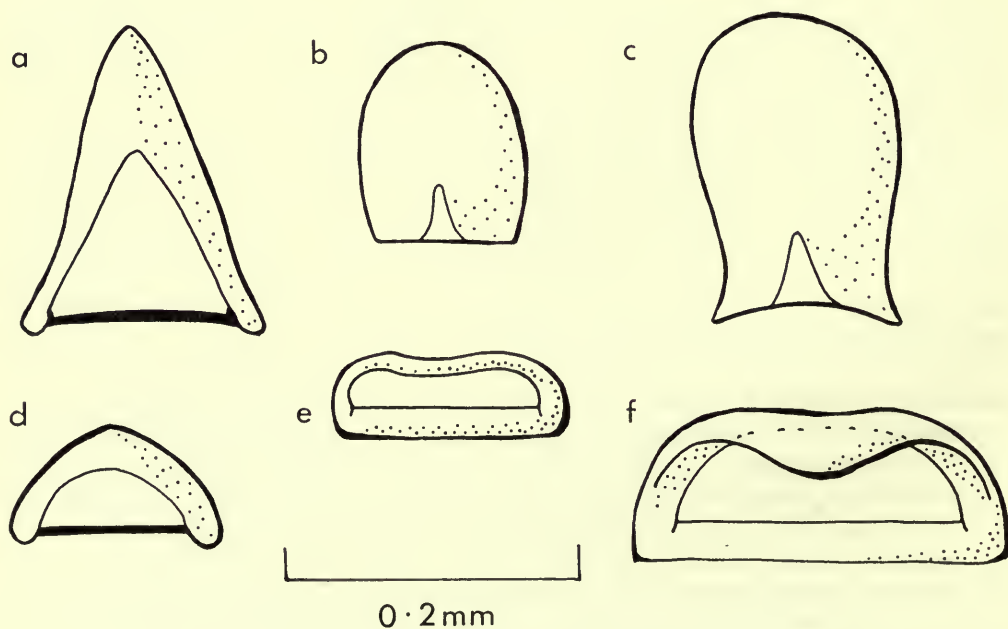


FIG. 8. Mandibles in *Hippoporida*. A-D. *H. senegambiensis*. A. Acute form, Senegal, Forest Coll. No. 3. B, C. Spatulate forms, Ghana, Achimota Coll. 14I. D. Rounded form, Ghana, Achimota Coll. 14I. E-F. *H. picardi*. E. Small sinuate form. F. Large, beaked sinuate form, Senegal, Marche-Marchad Coll. I, 33H.

The structure of the zoarium has been described above (p. 24). In a few cases the branched arms are not developed (Cape Blanco, 1922.9.12.1 and Forest Coll. No. 6), but in each of these, there has been a heavy settlement of barnacles upon the shell during the development of the Polyzoon.

The large interzooecial avicularia show a great deal of variation. The principal types are spatulate, semicircular and triangular, but there is some intergradation between these shapes. The young ovicell has a large membranous area frontally. Calcification reduces this first with a bar proximally above the orifice, and finally by progressive closure to a small circular distal area. In some zoaria the ectooecium is raised into tubercles distally and laterally, but generally the ovicell is smooth.

H. senegambiensis is distributed round the west African coast from northern Senegal to the Bay of Biafra, and has been found off the coast of Angola. It has not been reported from Madeira, or the Canary or Cape Verde Islands. In character *H. senegambiensis* is intermediate between, but distinct from, both *H. littoralis* and *H. picardi*. The great majority of the colonies are associated with shells of *Turritella annulata* Kiener, which are inhabited by the Pagurid *Diogenes ovatus*. *T. annulata* is found off the Ghana coast from 10–64 m., and is the dominant species of the silty-sand community or *Turritella* zone (see Bassindale, 1961 : 492, 500), which extends from 14.5–36 m. in depth. *D. ovatus* has a bathymetric distribution of 12–40 m. (see Forest, 1956 : 338, text-fig. 2).

24. *Hippoporidra picardi* Gautier

(Text-figs. 7D, 8E–F)

Hippoporidra picardi Gautier 1962: 254, text-fig. 22, Gulf of Salonika, Aegean Sea, 80–100m.

MATERIAL. “*Calyпсо*” Coll. I. Stn. 1, 21° 05' N., 17° 14' W., 10.v.56, 45–43 m., C1F. Stn. 6, 10° 19' N., 16° 33' 40" W., 16.v.56, 76–60 m., C2A, specimens 1, 2* and 3.

Marche-Marchad Coll. I. Sud de presque l'île de Cap Vert, 18.ii.54, 95 m., 30D and 33H.

Coll. III. As above, 46–50 m., 1A*. Baie de Gorée, 4A. 5610, IBC, 176–200 m., 6A*. Port Etienne, Mauritanie, vii.1953, 37–38 m., 7A. Au large de Gorée, Stn. 556, 95 m., 11A*. “Gerard Freca”, 2–15, 160–140 m., 12A ; N.W. Parar des Almadies, 170–145 m., 13A ; Dragage 5, 18.ii.54, 19A ; 4, as above, 97–98 m., 28B.

Forest Coll. Sud de Gorée, 25.iii.54, 95 m., No. 1*, with *Dardanus arrosor* (Herbst) and *Pagurus cuanensis* Thompson, No. 2.

British Museum, Cape of Good Hope, 1842.12.2.29, Belcher Coll.

H. picardi does not occur in the Achimota Collection.

DIAGNOSIS. Zoarium like that of *H. senegambiensis*. Zooecia larger and more recumbent. Frontal of autozooecia with 2–4 rows of pores. Orifice large, with well-developed denticles and a very small, rounded sinus. Orifices of cortical zooecia reduced in size. Interzooecial avicularia with triangular, spatulate and sinuate mandibles, some very large. Ovicell large with a rounded frontal area.

Dimensions. Lz 0.45 mm., lz 0.30 mm., Lz (cortical) 0.70 mm., lz (cortical) 0.50 mm., Lo 0.14 mm., lo 0.11 mm., Lo (cortical) 0.10 mm., lo (cortical) 0.06 mm., Lm 0.04–0.15 mm., lm 0.05–0.25 mm., Lov 0.20 mm., lov 0.20 mm.

H. picardi differs from both *H. senegambiensis* and *H. littoralis* in its larger zooecia, with more porous frontal, and in the shape of the orifice. The largest interzooecial avicularia, although closely related to those of *H. senegambiensis* with a rounded mandible, differ in their sinuous distal edge (see Text-figs. 8E–F). The ovicells, however, show no significant differences, except their generally larger size. Von Marten (1877 : 183) mentioned a Polyzoan with erect arms growing on a shell inhabited by a hermit-crab from 50 fath. off the South African coast (33° 59' S., 17° 52' E.), but did not give any further description. *H. picardi* is now known from the more northerly west African localities, and from the Cape of Good Hope. It is a deep-water form, and it is interesting that the first, and only previous record, is not from the Mediterranean proper, where *Hippoporida* does not occur (see Gautier, 1962 : 255), but from deep water in the Aegean. Gautier did not give the name of the hermit-crab associated with his specimen. The two species of crab named in the Forest Collection both extend in distribution to a depth of 100 m. *P. cuanensis* has the more northerly range, extending to the south coasts of Britain and Ireland.

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26. SUMMARY

The synonymies of three genera, *Hippoporina*, *Hippoporella* and *Cleidochasma* are given. Four species of *Hippoporina* are described ; *H. pertusa*, here found from Ghana, has a very wide geographical distribution ; *H. americana*, also widely distributed, is here recorded solely from waters of low salinity in Nigeria. *H. lacrimosa* and *H. acuta*, spp. n., are forms in which the avicularia differ from those of species previously described. *Hippoporella gorgonensis* is recorded for the first time from the eastern Atlantic, and is briefly compared with *H. multidentata*, a species from the Pacific and Indian Oceans. *H. pusilla*, here occurring in the eastern Atlantic from Madeira and the Cape Verde Islands only, is also described. Five species of *Cleidochasma* are described. *C. porcellanum*, which exhibits great variation in the character of the orifice, is a circum-tropical species, here considered to include *C. bassleri* ; *C. contractum*, another widely distributed species, is tolerant of colder waters. Ovicells are described for the first time in *C. oranense* and *C. brancoense*, species with large, erect zoaria. *C. rotundorum* has not been reported from west

Africa, but is found at Madeira, and has been previously confused with one of the species here included in the genus *Hippoporidra*. *Hippoporidra* is re-defined, and two species previously assigned to it, *H. granulosa* and *H. spiculifera*, are referred to *Cleidochasma*. Some associations between Pagurids, Gastropods, and encrusting organisms are briefly listed and the characters peculiar to the *Hippoporidra*-association described. Detailed examination, including X-ray photography, of the large amount of material available, has shown that the Gastropod shell is not eroded by the Polyzoan, and that the Mollusc is absent, so that the association, in Recent specimens at least, is between Polyzoan and Pagurid. *H. edax* and *H. janthina*, neither of which is west African, are briefly defined and described. The occurrence of the three west African species of *Hippoporidra* appears to be correlated with the species of Gastropod shell available, and with the bathymetrical distribution of the Pagurids with which these are associated. *H. littoralis* is an intertidal and shallow-water species, *H. senegambiensis* occurs in deeper waters, and *H. picardi*, which has been previously reported only from the Aegean, inhabits even greater depths, up to 200 m.

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